

Simple Guide to

Point of Care Ultrasound

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To our teachers,colleagues,students,
past and present. Most importantly, to
our families.



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Abbreviation and symbols

A4C	Apical four chamber
AAA	Abdominal aortic aneurysm
AbN	Abnormal
AIP	Anterolateral papillary muscle
ANS	Autonomic nervous system
A/w	Associated with
ARDS	Acute respiratory distress syndrome
BP	Blood pressure
CF	Colour flow
CO	Cardiac output
Desc. Aorta	Descending aorta
DVT	Deep vein thrombosis
EFAST	Extended focused assessment with sonography in trauma.
E.g	Exempli gratia (for example)
FAST	Focused assessment with sonography in trauma
HR	Heart rate
ICS	Intercostal space
IVS	Interventricular septum
IVC	Inferior vena cava
IW	Inferior wall
LA	Left atrium
LCC	Left coronary cusp
LRA	Left renal artery
LVF	Left ventricular function
LV	Left ventricle
LUQ	Left upper quadrant
N	Normal
NCC	Non coronary cusp
PA	Pulmonary artery
PE	Pulmonary embolism
PLAX	Parasternal Long Axis
PmP	Posteromedial papillary muscle
PSAX	Parasternal Short Axis

RA	Right atrium
RCC	Right coronary cusp
RRA	Right renal artery
RUQ	Right upper quadrant
RVOT	Right ventricular outflow tract
RV	Right ventricle
RWMA	Regional wall motion abnormality
SA	Sinoatrial (node)
SMA	Superior mesenteric artery
SV	Stroke volume
S4C	Subcostal four chamber
TGC	Total gain control
TPR	Total peripheral resistance
UGIT	Upper gastrointestinal tract
<	Less
>	More
≤	Equal or lesser
≥	Equal or more

Preface

You are the paramedic. The major trauma patient in your ambulance is restless and breathless. There was no blood pressure nor oxygen saturation recorded from the start but he has a feeble radial pulse. He has a short neck and you cannot appreciate his trachea location. You put your stethoscope but with the wailing ambulance sirens, you cannot hear a thing. You reach for the ultrasound and find the batwings – no sliding sign throughout the entire left hemithorax. You put in a 14G cannula at the left fifth intercostal space. Minutes later, the patient's breathing eases.

You are the medical officer. You receive the trauma patient with a left needle thoracocentesis in place. His blood pressure is 80/40mmHg. There is no obvious external bleeding. His body habitus bears a flabby abdomen. You put the ultrasound probe at the abdomen. Hepatorenal – splenorenal – suprapubic; all appeared clear. You then have a look at the heart from subxiphoid – you see poor right ventricular filling due to fluid collection at the pericardial space. You immediately call your senior to arrange for pericardiocentesis.

This book aims to guide the novice in point-of-care ultrasound and most of the illustrations in the book come from our personal collections. You may have attended a course and forgotten half of the things to look for. Or you have not had the opportunity to attend a course but had to man the graveyard shift solo. Or you were intrigued by the inspect – palpate – percuss – auscultate – insonate mantra. It's made to fit in your pocket. Reach for it during POCUS doubts. We hope that it will be of value to students at every level of training.

Khadijah Poh

Foreword

Thank you for giving me the opportunity to deliver the foreword in this book.

Point-of-care ultrasound (POCUS) is increasingly gaining importance in medicine, more so in emergency medicine fraternity. Its application provide an essential adjunct tool during the patient assessment and allowing further in depth management the undifferentiated patient. This leads to a more guided approach in the realm of uncertainty, giving an idea amidst the ambiguity. When engaging time-critical conditions, clinical bedside tools will be of value.

This "Simple Guide to Point-of-Care Ultrasound" is meant to guide the novice during basic point of care ultrasound course and subsequently serve as bedside reference.

Its simplified approach may facilitates the reader in giving an idea on how to perform POCUS adequately and benefits the patients clinical needs.

Congratulations to the contributing authors in making this simple book a success.

Datuk Dr Mahathar Abd Wahab

Consultant Emergency Physician

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Ultrasound Basics

Ultrasound Basics

Objectives

1. Understand ultrasound principles and its basic physical properties.
2. Able to select and use an appropriate probe that will provide optimal penetration of the anatomic region of interest.
3. Able to maximize image quality using gain and depth.

Knobology

1. Knobology is all about the knobs and buttons in ultrasound and how you manipulate them to obtain the best image possible.
2. There are many sort of ultrasound machine available in the market, from simple portable ultrasound to high-end big ultrasound machine. However, for beginners, there are few basic buttons and function that you need to know, regardless of what type or how complicated the buttons are.
3. Here we explore the different knobs and buttons available. There may be minor differences between the ultrasound models, but mostly basic functions and labels are similar.



1.1 Various ultrasound type and models.

Important Buttons



1.2 Ultrasound keyboard

1. **On/Off Button.**
2. **Exam/Preset:** to select probe and type of exam (e.g cardiac,vascular)
3. **B mode :** Brightness mode (2D image).
4. **M mode: Motion mode.** It display returning echoes over a time axis.
5. **Depth:** Enables the operator to view and interpret deeper or shallower structures.Increased depth will reduced resolution.
6. **Freeze:** Produce a static image for taking measurements and archiving.
7. **Trackball / Trackpad:** Equivalent of the computer mouse. Used to move the cursor around the screen for selecting option or typing.
8. **Gain :** Increase or decrease the overall brightness of the image.
9. **TGC:** Time gain compensation. Used to increased or decreased image brightness at specific depth.
- 10.**CF:** Colour flow (not all ultrasound machine have this feature). Shows blood flow in vessels.

3 Basic Probes



1.3 Three main probes

A) **Linear probe:** To see superficial structures or in very thin subjects.

Useful for:

- i) Lung ultrasound (sliding sign).
- ii) Airway ultrasound.
- iii) Vascular ultrasound (deep vein thrombosis).
- iv) Ultrasound-guided cannulation procedures (venipuncture, pleural tapping, pericardiocentesis).
- v) Bowel (for thin adult or paediatric age group, especially to look for appendicitis or intussusception).

B) **Phased array /Cardiac probe:** Generally use for cardiac ultrasound in adult and paediatric patients.

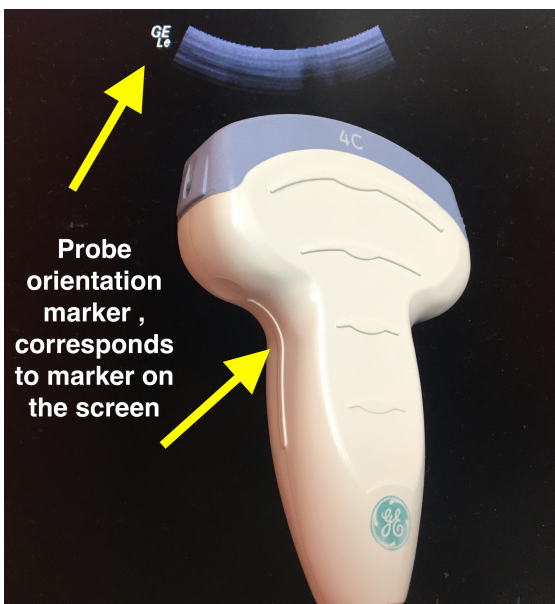
C) **Curvilinear /Convex probe:** To see deeper structures than a linear probe. Commonest probe in emergency settings.

Useful for:

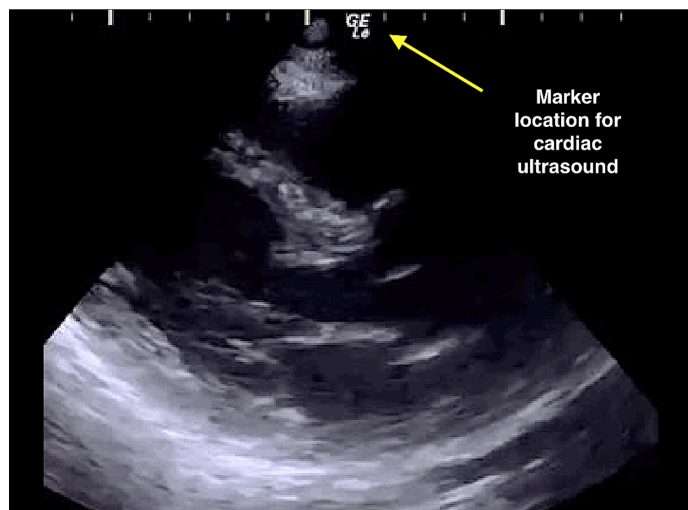
- i) Abdomen exam/FAST scan.
- ii) Lung ultrasound.
- iii) Cardiac ultrasound in the absence of cardiac probe.
- iv) Vascular ultrasound (in big sized adult or with thick tissue).

Screen Orientation

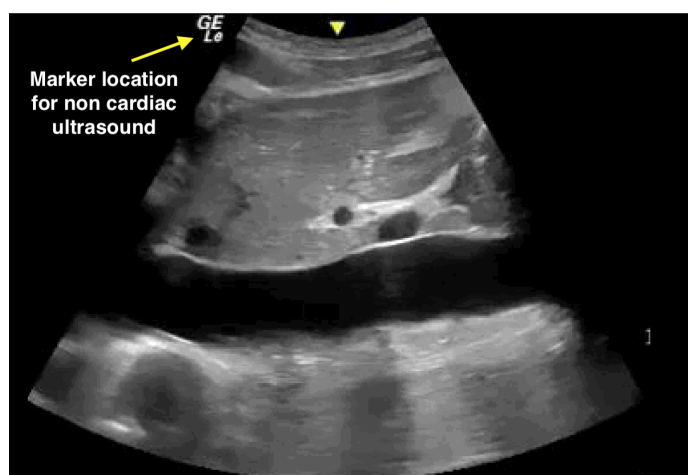
During the early evolution of diagnostic ultrasound from the 1940s to 1970s, general medical and cardiac ultrasound imaging developed two independent conventions for displaying images on the screen. General medical opt for the probe marker corresponding to the left side of the screen. Majority of specialties performing diagnostic ultrasound follow this convention including radiology and emergency medicine. Cardiac ultrasound, utilises a convention with probe marker corresponding to the right side of the screen. This orientation is maintained throughout cardiac ultrasound imaging.



1.4a Marker orientation in relation to screen orientation.



1.4b Cardiac screen orientation.



1.4c Non cardiac screen orientation.

Holding the Probe

The basic rules in holding the probe are :

1. The operator should be comfortable holding the probe.
2. The probe held must be stabilised against the patients' body.

To achieve this,

- a) The probe should be held like a pen, with the thumb and index finger.
- b) The remaining fingers (4th and 5th fingers) can be held against the probe or placed on the patients' body surface to anchor the probe and maintain its location and stability.

All probes have a notch or marker on one side that corresponds with the screen marker for orientation. For non-cardiac ultrasound, the marker should point towards cranial (patient's head) for vertical scanning and patient's right for transverse scanning.



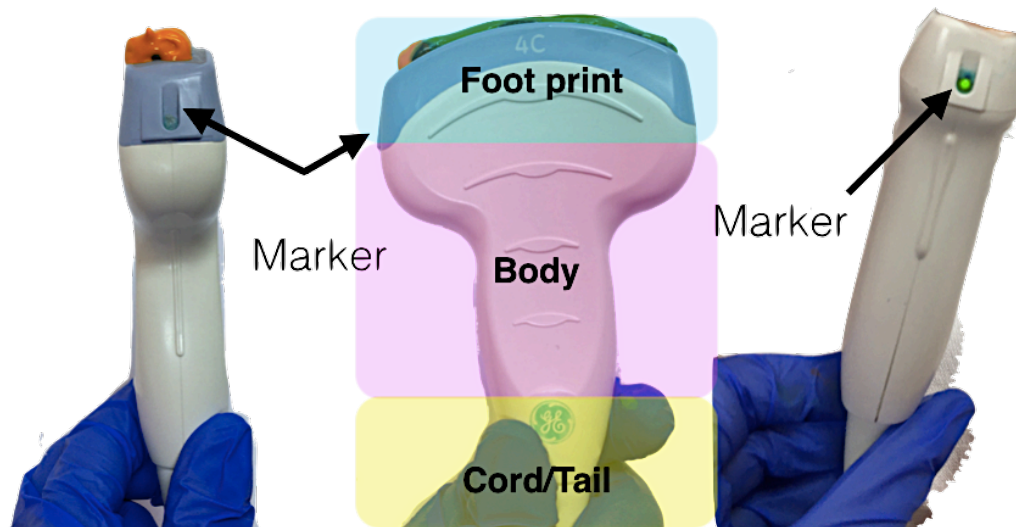
1.5a Incorrect hand position. The hand is far from the probe body.

1.5b Correct position in holding the probe. Use little finger as an anchoring point.

Probe Movement

The ultrasound probe can be moved in 5 different ways:

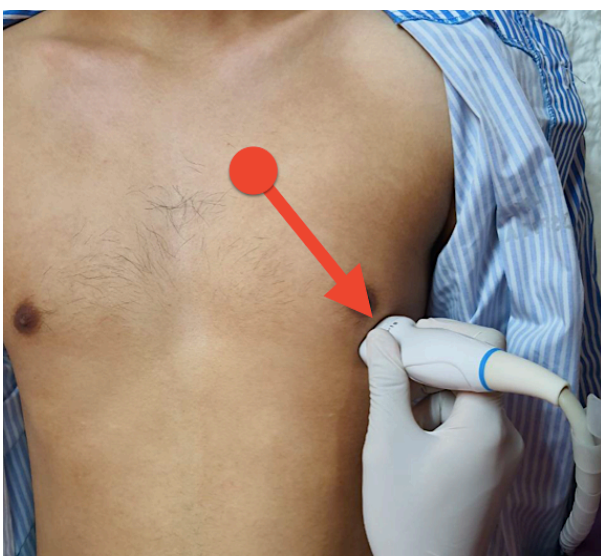
1. Sliding
2. Rocking
3. Tilting
4. Rotating
5. Sweeping



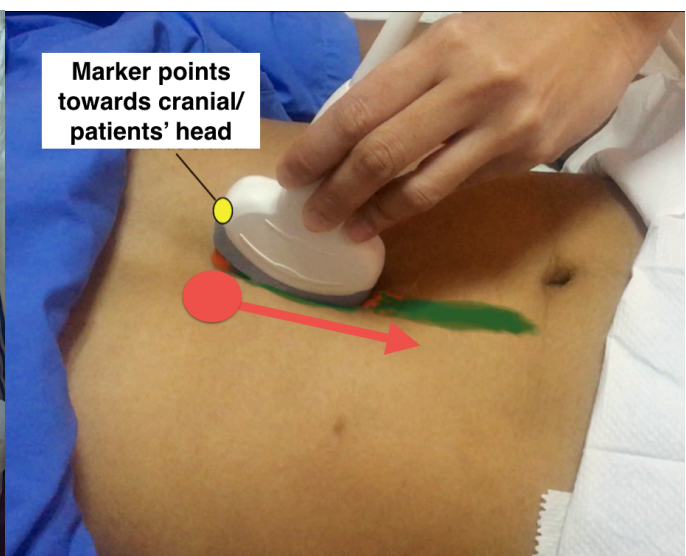
1.6 Ultrasound probe anatomy.

1. Sliding

The probe is held at a fixed angle and the entire probe is moved in any straight direction e.g diagonally, horizontally or vertically.



1.7a Probe sliding diagonally.



1.7b Probe sliding up/down vertically.

2. Rocking

The probe is held firmly in place and rocked the probe side to side. Move the handle horizontally side to side while maintaining probe footprint on the same location.



1.8a Probe rocking to the left.



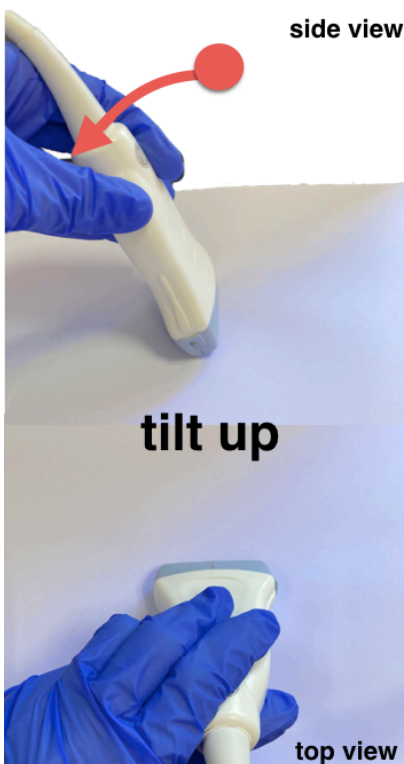
1.8b Neutral position.



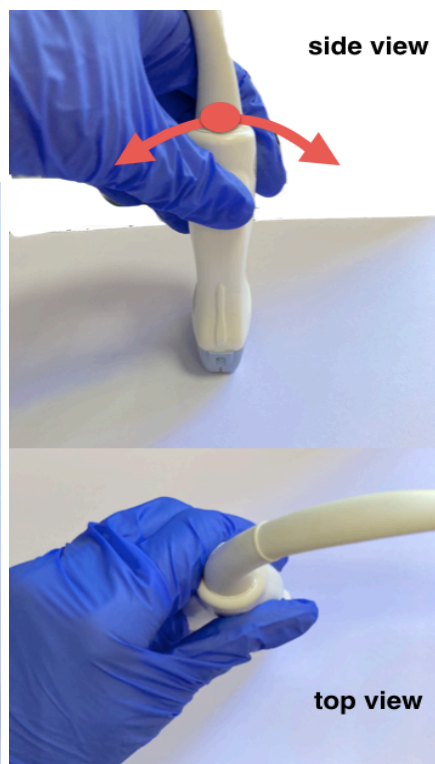
1.8c Probe rocking to the right.

3. Tilting

The probe is held firmly in place and angled up and down. Move the handle vertically up or down while maintaining the probe footprint on the same location.



1.9a Tilting the probe up by angle the cord downward.



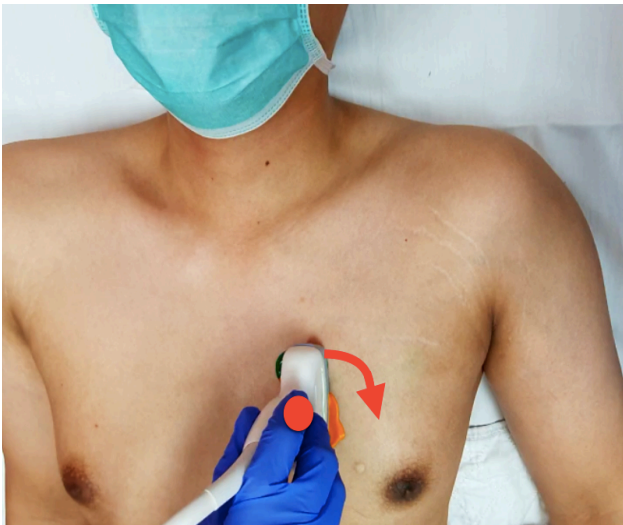
1.9b Probe in neutral position.



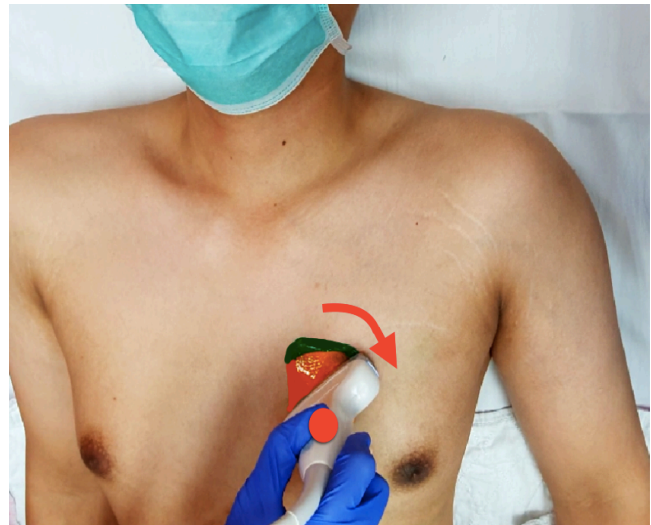
1.9c Tilting the probe up by angle the cord upward.

4. Rotating

The probe position is held constant on the same location while rotating along its central axis (clockwise or anti-clockwise).



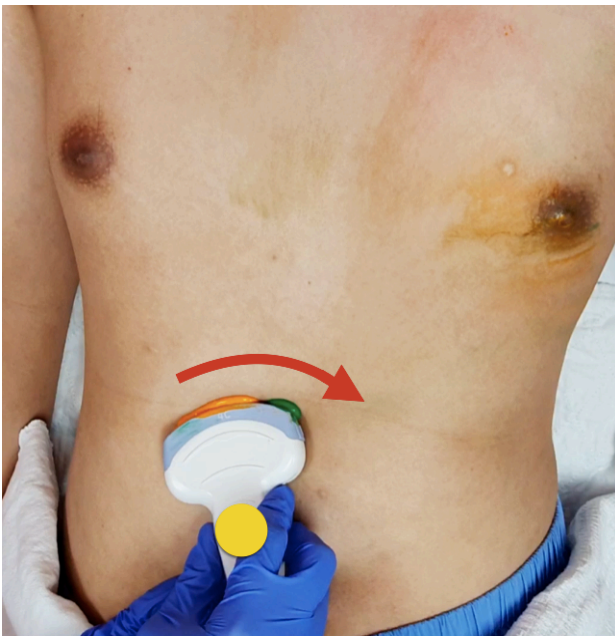
1.10a Probe rotation clockwise from PLAX to PSAX.



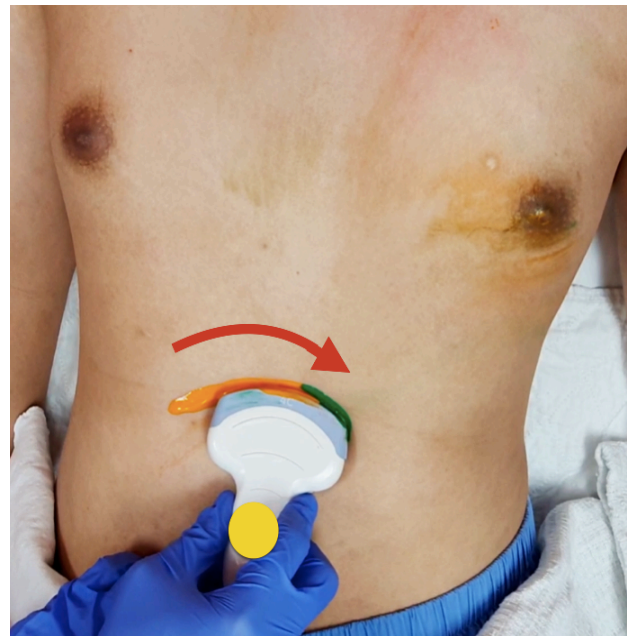
1.10b The probe foot print moves clockwise while the probe body maintain on the same axis.

5. Sweeping

The footprint is moving along the same axis while the handle maintains the same point.



1.11a Getting subxiphoid four chamber view by sweeping the probe from right to left.



1.11b The probe footprint moves sideways while maintaining the handle on the same axis.

Nomenclature

1. Echogenicity : ability of a structure to produce echo.

a) **Anechoic**

No echo and appears black in ultrasound, usually due to presence of fluid/blood.

b) **Hypoechoic**

Less reflective due to less amount of echo, appears darker gray on screen. Example structures are LN, prostate.

c) **Hyperechoic**

Highly reflective structures, usually solid organs, muscle or nerve. Calcified structures like bone form a hyperechoic line with hypoechoic shadow due to high density/solid elements.

d) **Isoechoic**

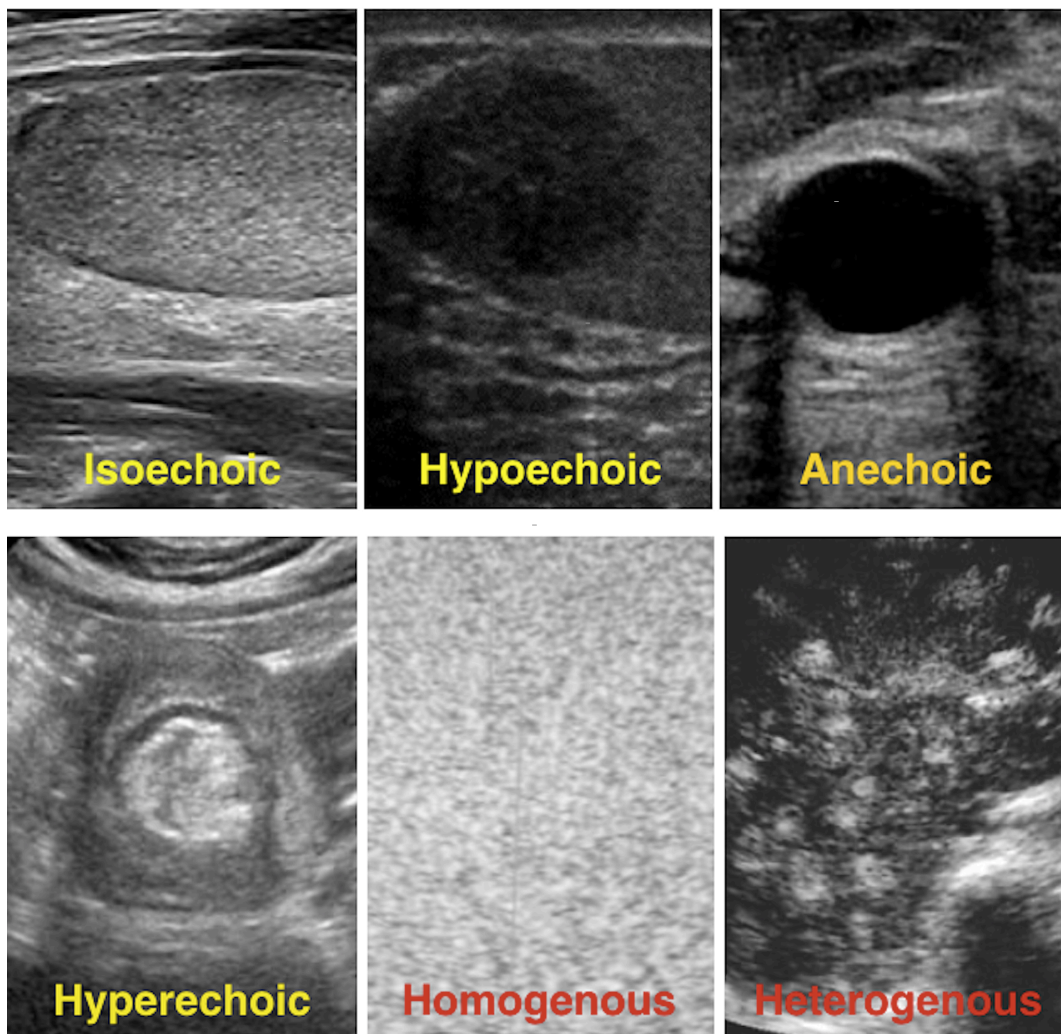
Having similar echogenicity to a neighbouring structure.

e) **Homogenous**

Organ parenchyma uniform in echogenicity.

f) **Heterogenous**

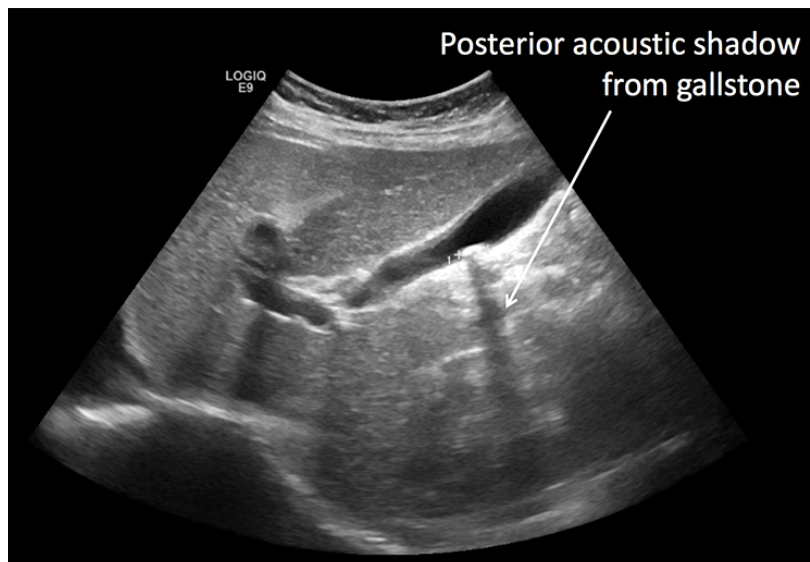
Organ parenchyma not uniform in echogenicity.



1.12 Schematic diagram to demonstrate the relative echogenicity of various structures.

2. Posterior Acoustic Shadowing

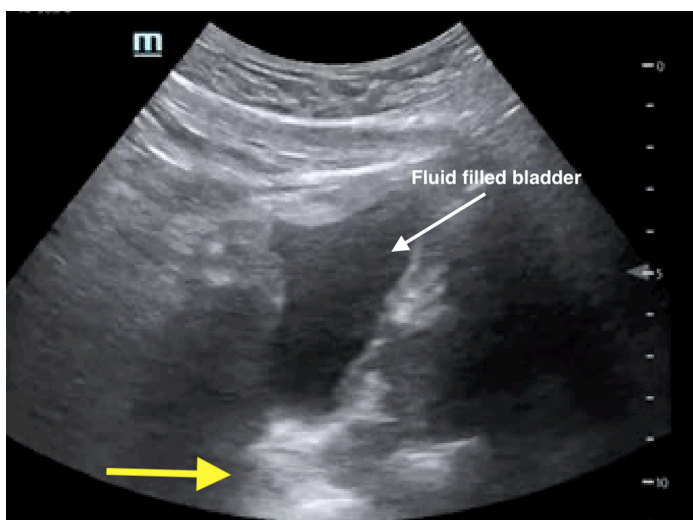
- a) Is an ultrasound image characterised by signal void behind structures that strongly absorb ultrasound waves.
- b) Characterised by hypoechoic region below a linear hyperechoic (surface of the object). Usually, the structures are solid/hard e.g stones, bones.



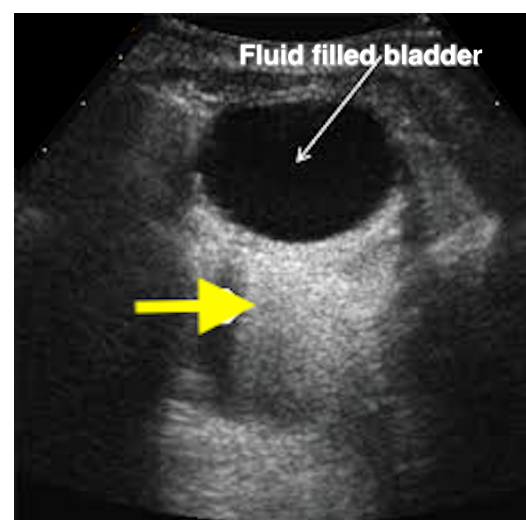
1.13 Hyperechoic gallstone with posterior shadowing.

3. Posterior Acoustic Enhancement

- a) Is a phenomenon of an ultrasound wave pass through an area of low resistance.
- b) It refers to the increased echogenicity (slight hyperechoic) deep to the structure.
- c) Usually, they are structures that contains fluid. E.g urinary bladder, gallbladder, ovarian cyst, or any cyst that contains fluid.



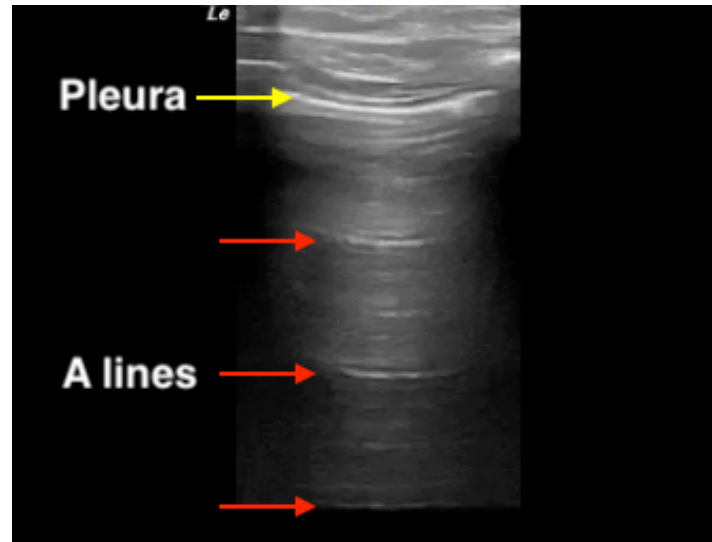
1.14a Hypoechoic structure with posterior acoustic enhancement.



1.14b Anechoic structure with posterior acoustic enhancement.

4. A-line

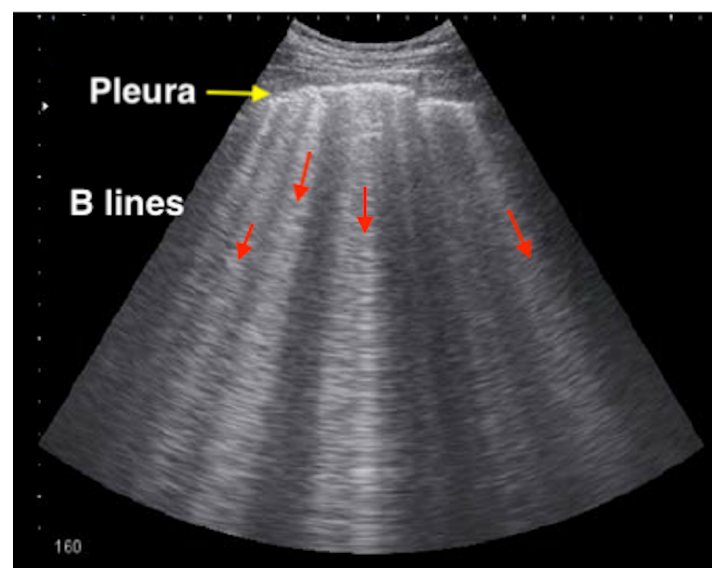
- a) Horizontal artifacts from the reverberation of an ultrasound echo.
- b) They are repeated reflection through the image caused by an initial reflection at a highly reflective interface e.g pleura, pericardium.
- c) Mainly occurs where there is air inside the organ/structures, e.g Lungs. A-lines also can be seen in pneumoperitoneum or pneumomediastinum.



1.15 Reverberation artifacts (A lines), noted that the distance of each lines are similar.

5. B-line

- a) Vertical artifacts originating from the pleural line.
- b) Expanding band of a hyperechoic artifacts to the end of the ultrasound window.
- c) Have been likened to the beam of a flashlight.
- d) Considered clinically significant if more than 3 lines present, it is an indication of pulmonary interstitial syndrome.



1.16 Multiple B lines in lung with interstitial oedema

Basic Cardiac Ultrasound

Basic Cardiac Ultrasound

Objectives

1. Familiarize with technical performance, interpretation and limitation of 2D cardiac ultrasound.
2. Understand the basic aspect of cardiac ultrasound and the correlation with cardiac anatomy, physiology and pathophysiology.
3. Learn the appropriate technique and basic cardiac ultrasound views.

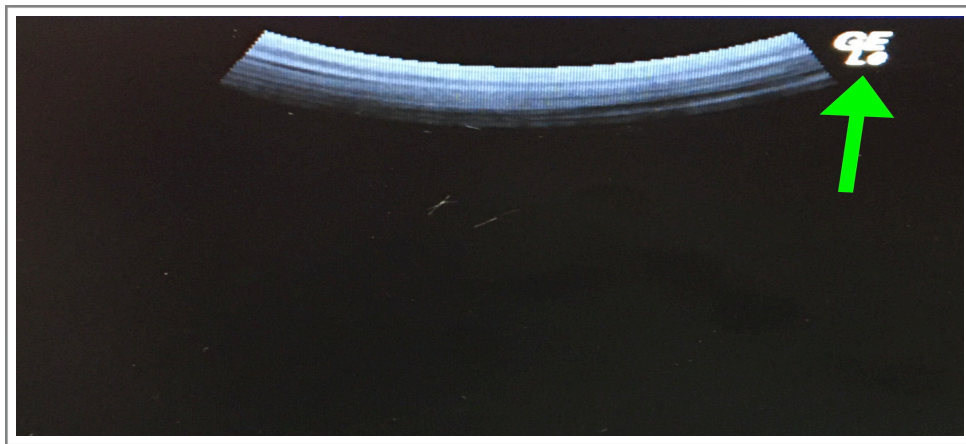
Technical requirement

1. Probe

- a) Phased array probe / cardiac probe
- b) Curvilinear probe (if cardiac probe not available)

2. Technical requirement of the probe selection

- a) Phased array probe
 - Marker on the screen should be on the right side
- b) Curvilinear probe
 - Marker usually on the left side. However if you can reverse the marker to the right side (in screen setting), then take this choice.



2.1 Different manufacturers have different label of ultrasound screen marker. Here is labelled as 'GE'.

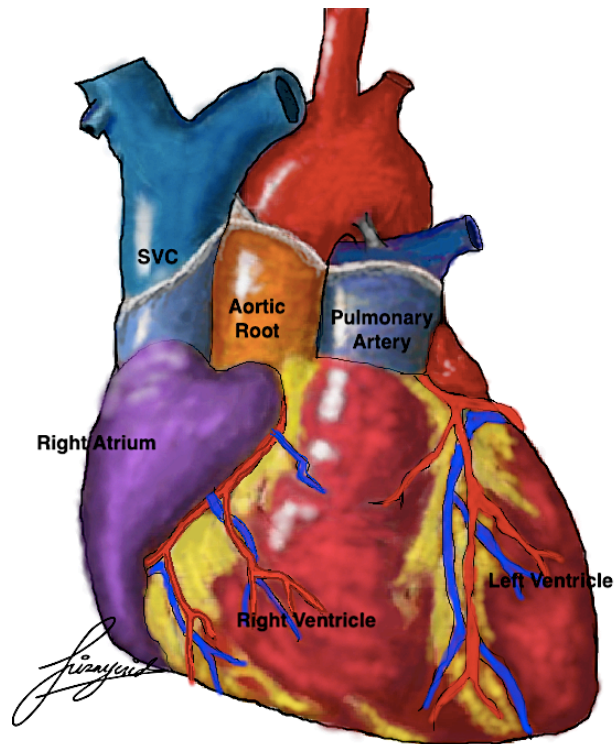
3. Patient Position.

- Supine , Semi-left lateral , or semi-recumbent.

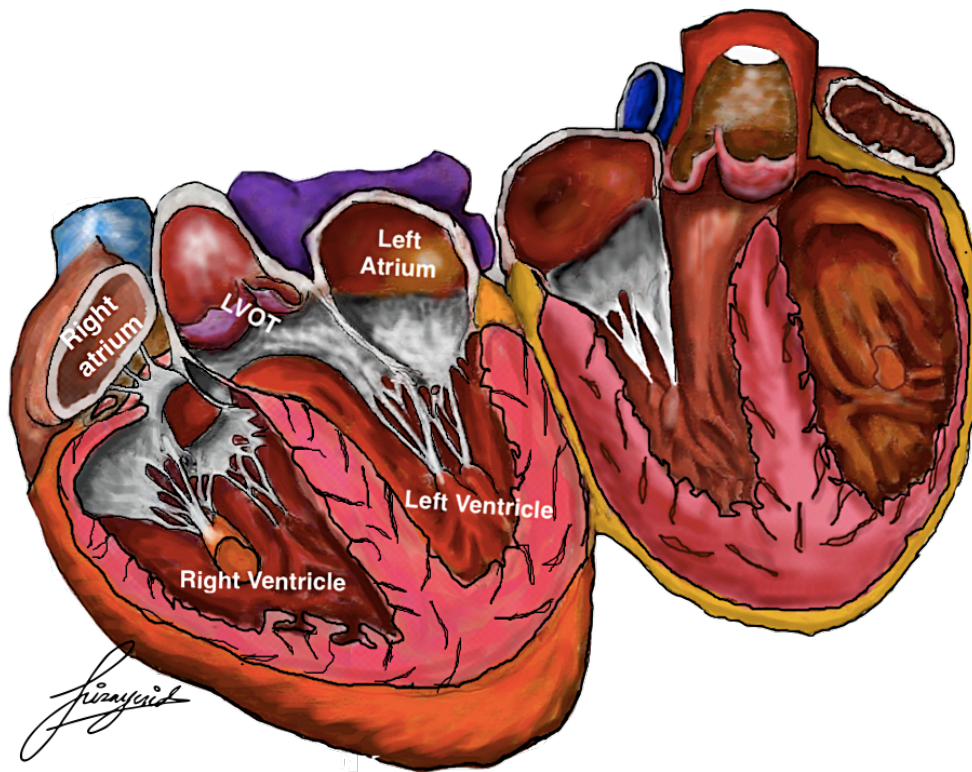
4. Depth setting

- Depending on patient's body habitus and cardiac size.
- Start at 15 cm.
- Increase depth in obese patient and cardiomegaly e.g up to 20 cm.

Anatomy of the heart



2.2a Normal anatomy of the heart

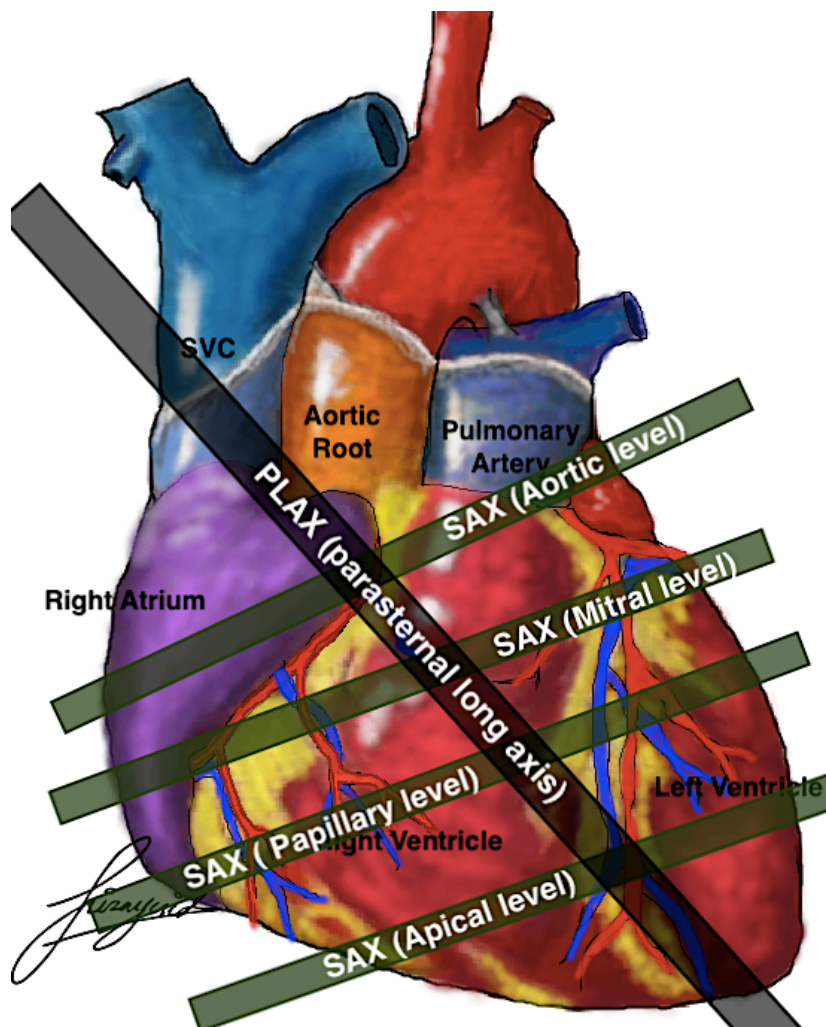


2.2b Normal heart vertical cut (view can be seen in PLAX view)

Ultrasound technique and views

For basic cardiac ultrasound, beginners must know these views:

1. **PLAX (Parasternal Long Axis)**
2. **PSAX (Parasternal Short Axis)**
 - a. Aortic view
 - b. Mitral valve view
 - c. Papillary muscle view
 - d. Apical view
3. **Apical Four Chambers**
4. **Subxiphoid Four Chambers**



2.3 Cut sections of the heart and its correlation with ultrasound views.

Parasternal Long Axis View (PLAX)

1. Patient position :

- a. Supine
- b. Left lateral decubitus
- c. Semi recumbent

2. Depth : start with 12 cm and then adjust accordingly until the descending aorta is visible at the base of the screen.

3. Technique :

- a. The probe is placed transversely just to left side of the sternum with marker pointed to patients' right shoulder at the level of 3rd intercostal space.
- b. Move the probe downward each intercostal space (ICS) until you see a moving heart (between 3rd ICS to 5th ICS).
- c. Move the probe one space below to ensure that the best image has been identified.

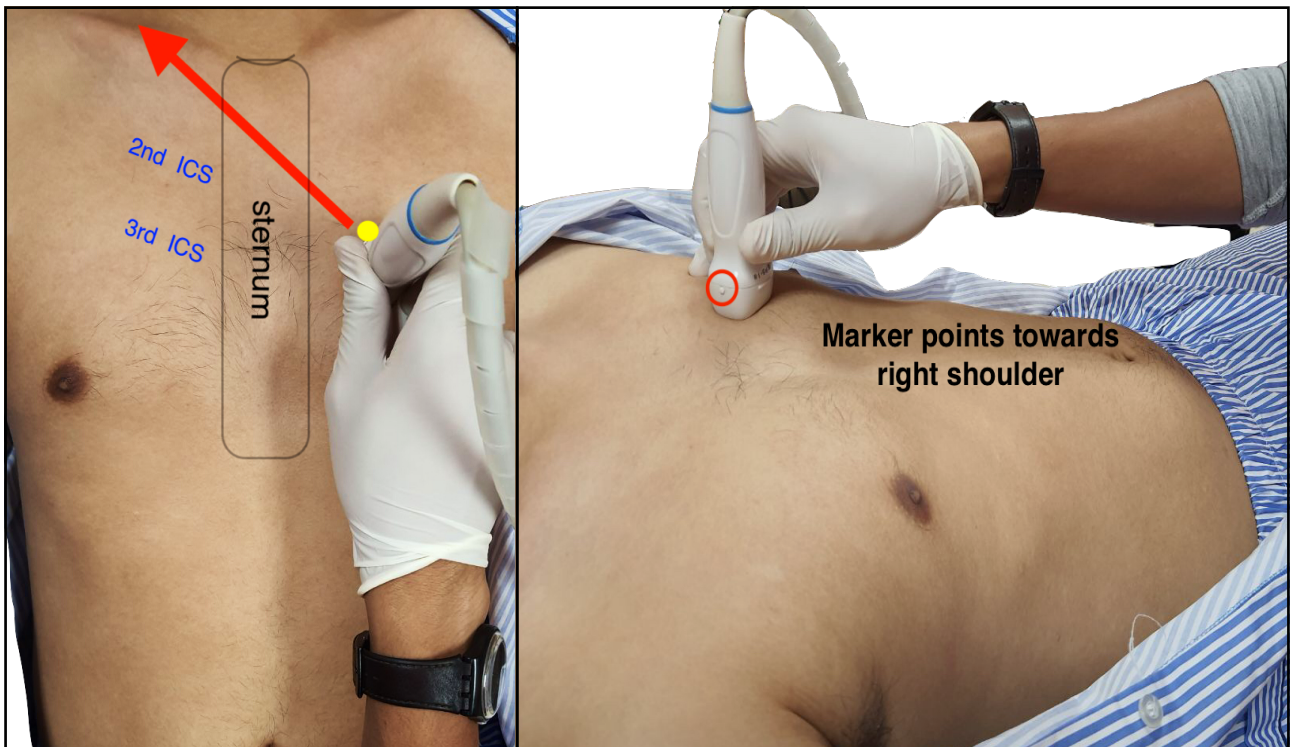
4. Structures that need to be identified in PLAX view :

1. RV (right ventricle)
2. LA (left atrium)
3. LV (left ventricle)
4. LVOT (left ventricular outflow tract)
5. Mitral valve
6. Aortic valve
7. Descending aorta

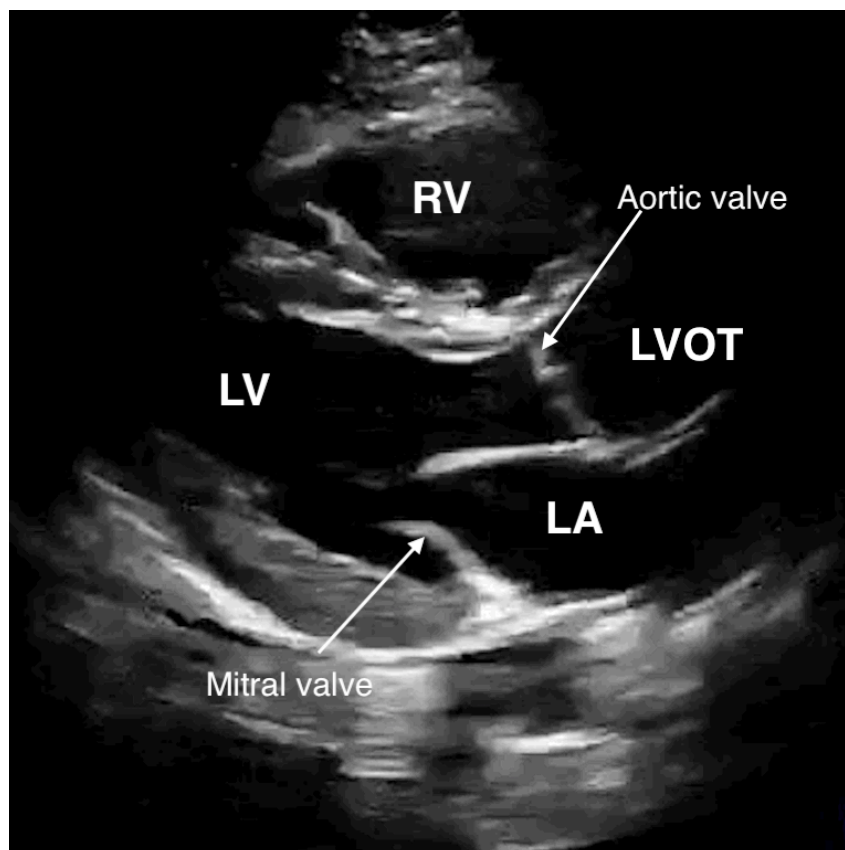
5. Abnormalities that can be detected in PLAX view:

- I. Pericardial effusion (fluid can be seen above the descending aorta).
- II. Pleural effusion (fluid below the descending aorta).
- III. Aortic dissection (evidence of dissection flap).
- IV. Aortic root aneurysm (normal Aortic root diameter <4 cm).
- V. LV contractility (anterior mitral valve leaflet that almost touching/ approximate the septum indicates a good LV function).

PLAX (Parasternal Long Axis)



2.4 Probe location for PLAX view in normal patient. The probe marker is pointing towards patient's right shoulder.



2.5 Ultrasound image for Parasternal long axis view.

Parasternal Short Axis View (PSAX)

1. Patient position :

- a. Supine
- b. Left lateral decubitus
- c. Semi recumbent

2. Depth : start with 12 cm and then adjust accordingly until the inferior wall of LV at the base of the screen.

3. Technique :

- a. From the initial position of PLAX view, with the mitral valve at the centre of the screen, rotate the transducer 90 degree clockwise (the marker pointed towards patients' left shoulder).
- b. In PSAX view, the LV must be a round shape. Off-axis image ,the LV will appear elliptical or D shape (do not interpret/read an off-axis image as it will be misleading).
- c. At the same level and same axis of PSAX, tilt the transducer up to see the Aortic view, and downward for papillary muscle and apical view.

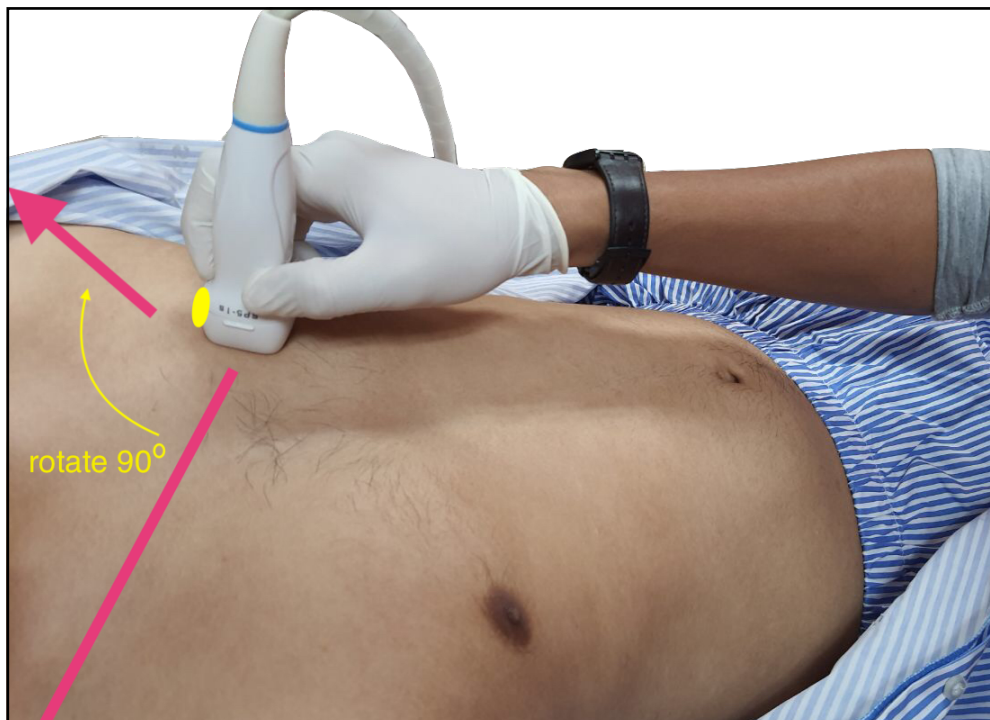
4. Structures that need to be identified in PSAX view :

1. **Mitral level** - LV wall for any RWMA
- RV (normal will be crescent shape)
2. **Aortic level** - LA ,RA, RV
- Pulmonary Valve
- Pulmonary artery
3. **Papillary level** - LV wall for any RWMA
- RV (normal will be crescent shape)
4. **Apical level** - LV wall for any RWMA

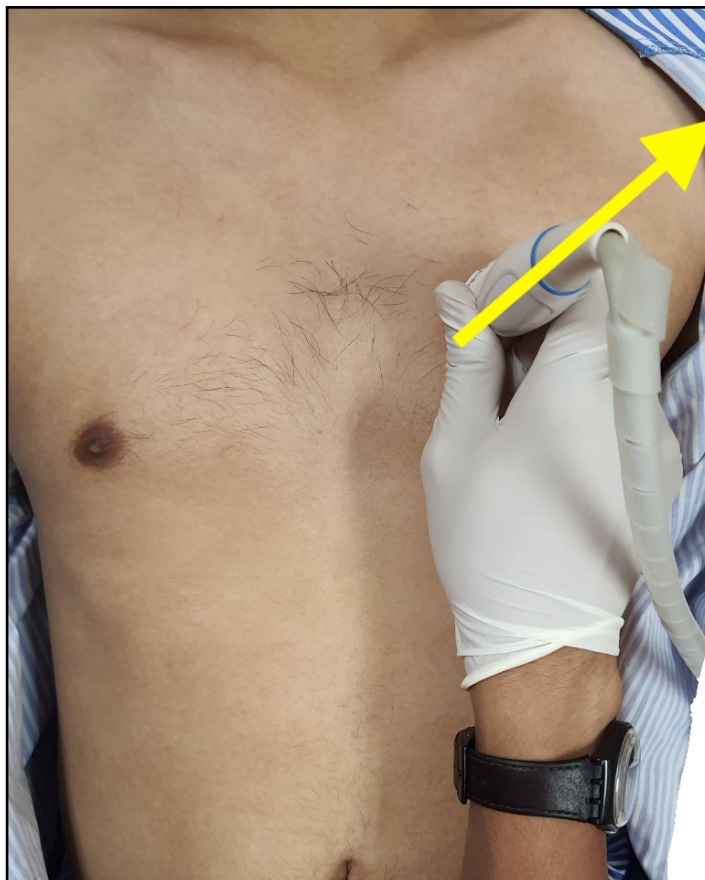
5. Abnormalities that can be detected in PSAX view:

- I. RWMA (Regional motion abnormalities) of the left ventricle. Can be assessed at the level of Mitral, Papillary and Apical view.
- II. Enlarged and D shape RV (when there is high pressure/volume in right ventricle) with a paradoxical movement of septal wall, especially in cor pulmonale.

PSAX (Parasternal Short Axis)



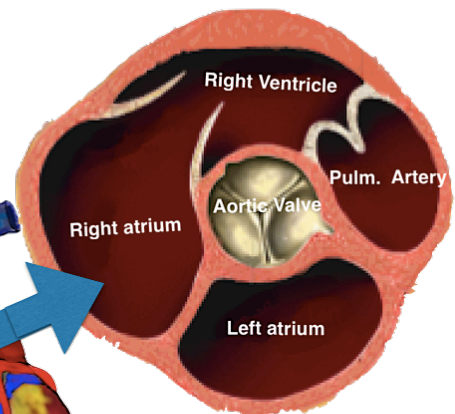
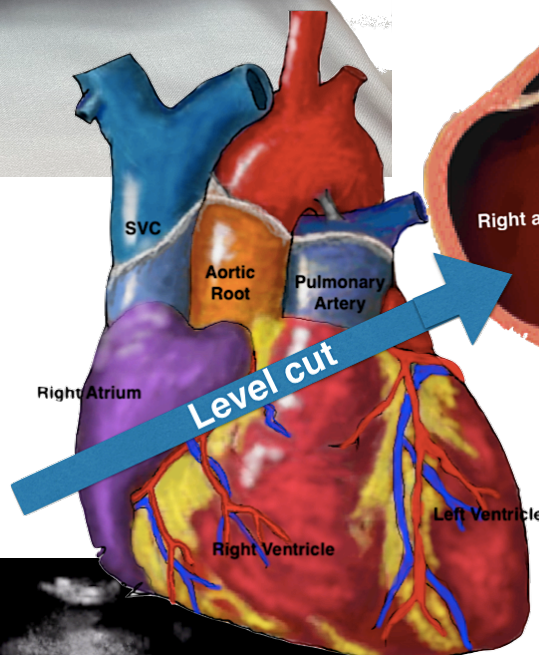
2.6 To get PSAX view, the probe need to rotate 90 degree clockwise from initial location for PLAX view.



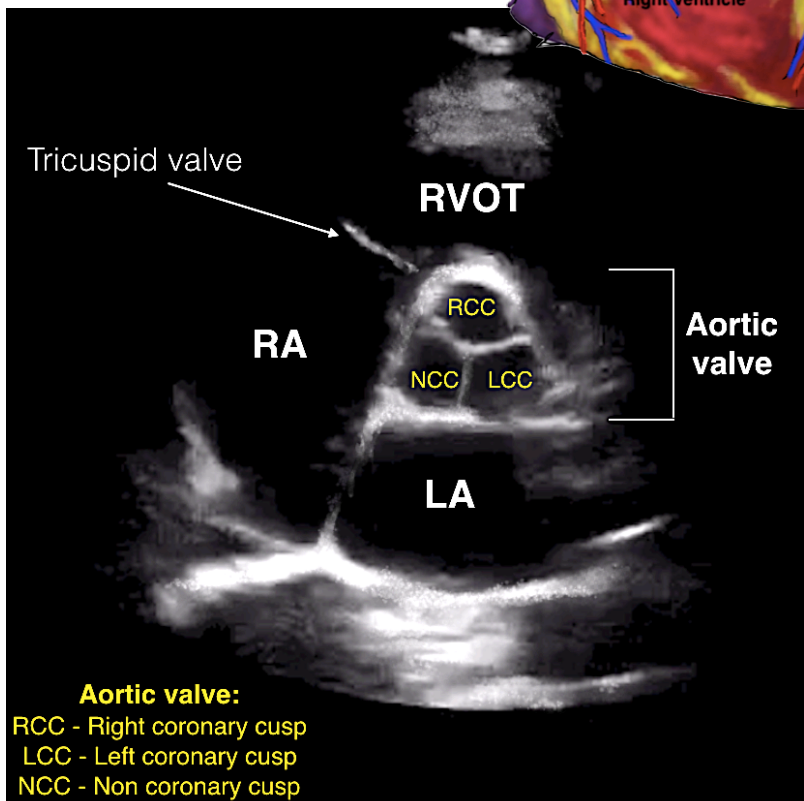
2.7 The marker is pointing towards patients' left shoulder

PSAX (Aortic level)

2.8a With the probe fixed for PSAX view, slightly tilt it upward (probe body angled down) to view the aortic valve.



2.8b Cut plane of Aortic view in PSAX

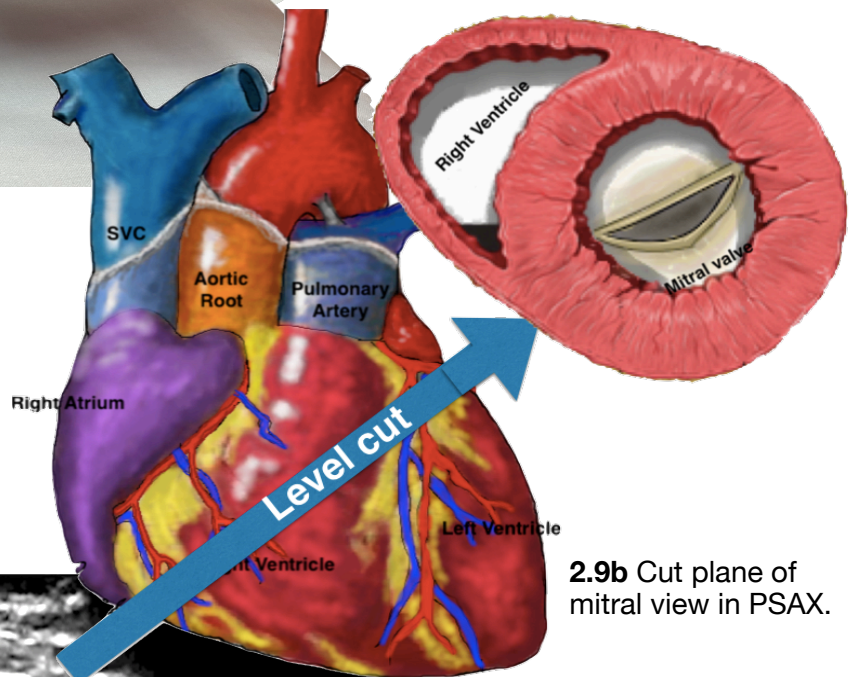


2.8c Appearance of aortic valve during diastole resembles "Mercedes star".

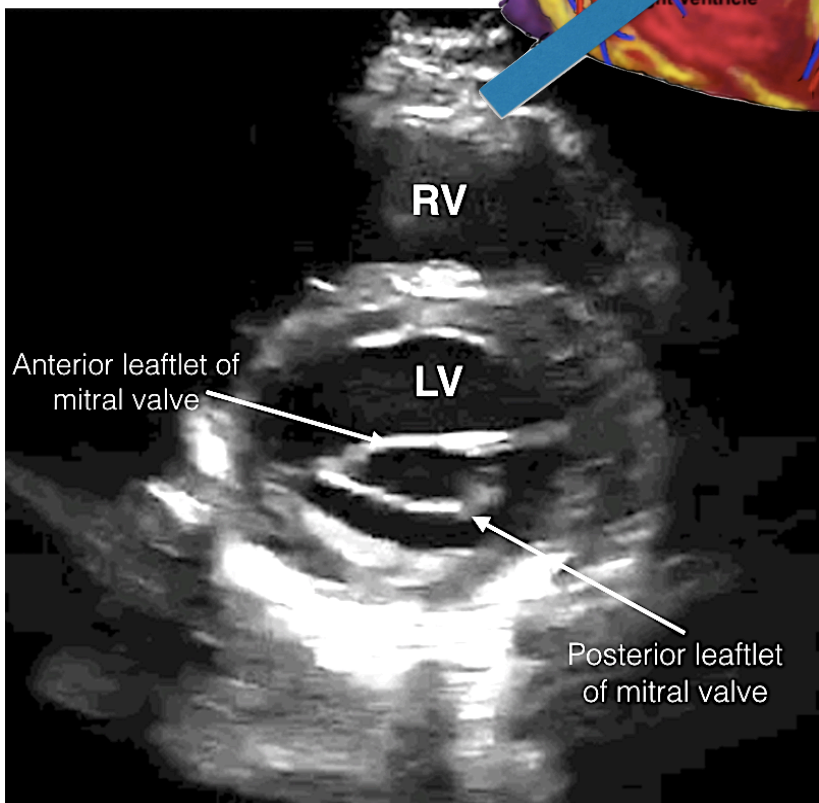
PSAX (Mitral level)



2.9a By tilting the probe downward but staying perpendicular 90 degree, you can view the mitral valve plane.

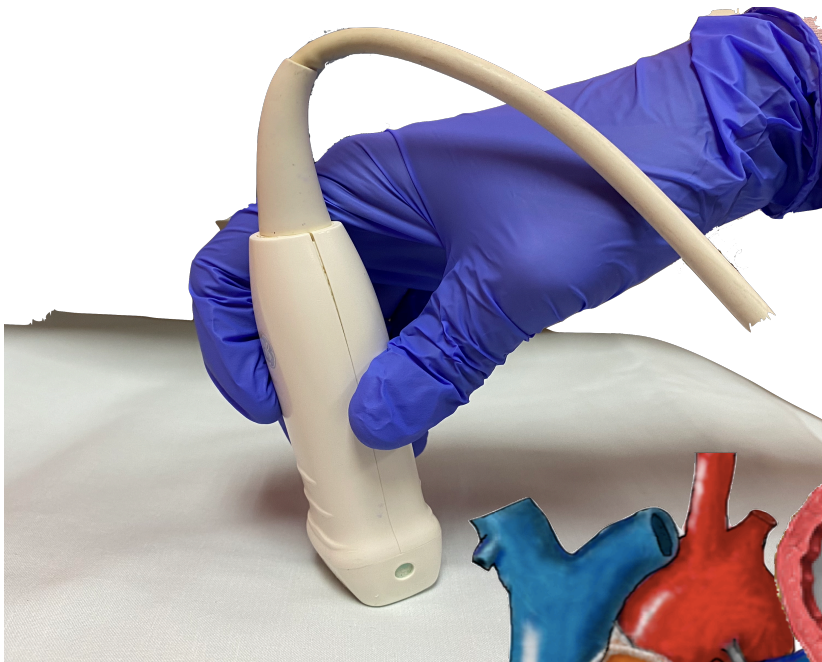


2.9b Cut plane of mitral view in PSAX.

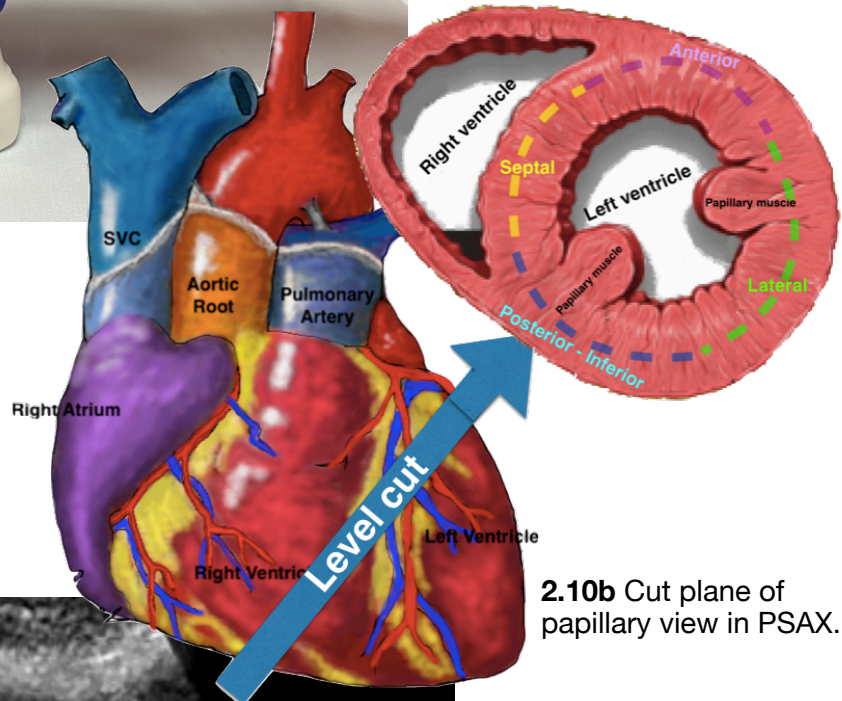


2.9c The mitral valve is seen orthogonally with its anterior and posterior leaflet. This view is ideal to observe the opening and closing motion of the mitral valve which has been compared to moving fish-mouth. It is mainly to assess mitral valve, and should not be used to assess LVF/ RMWA since its too near to the base of ventricle.

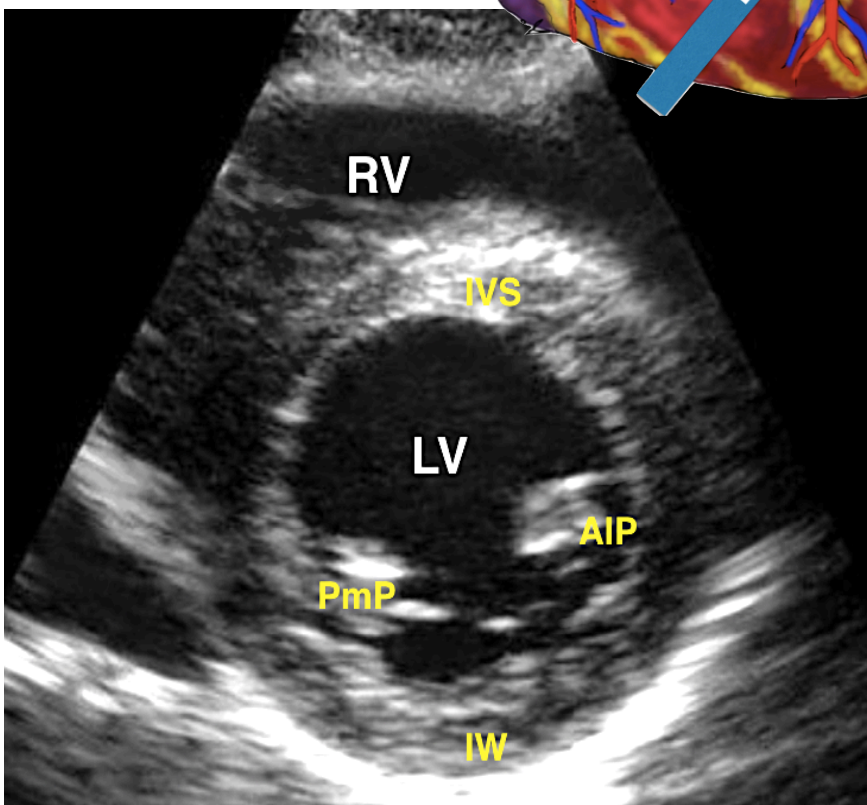
PSAX (Papillary level)



2.10a Tilt the probe further downwards towards the apex until you lose the mitral valve.



2.10b Cut plane of papillary view in PSAX.

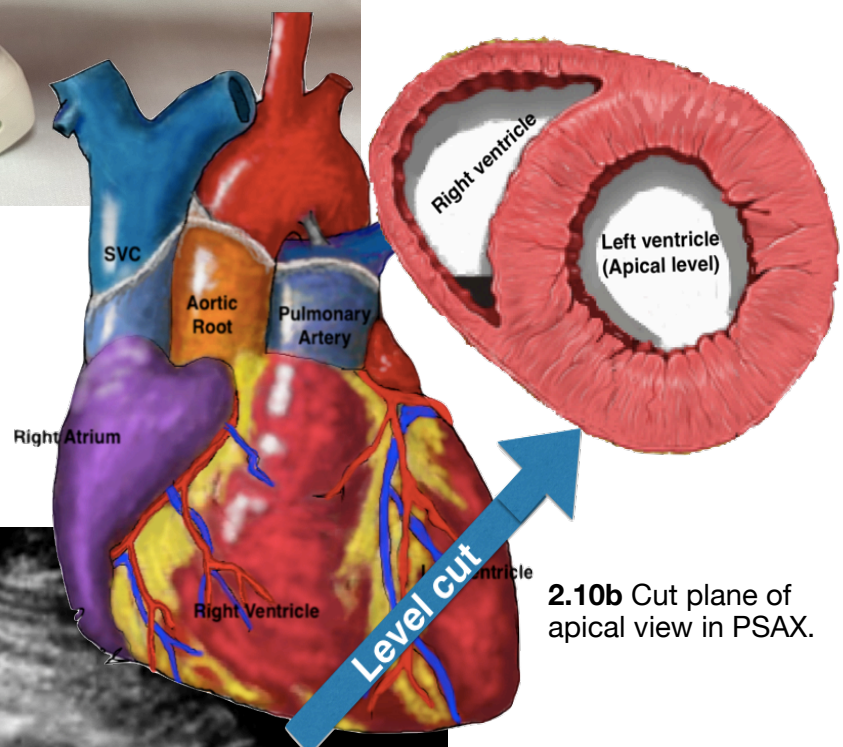


2.10c While tilting, make sure the LV stays round. If the LV becomes oval, you should move up one or two ICS. This view is useful to assess the left ventricular function and any RWMA.

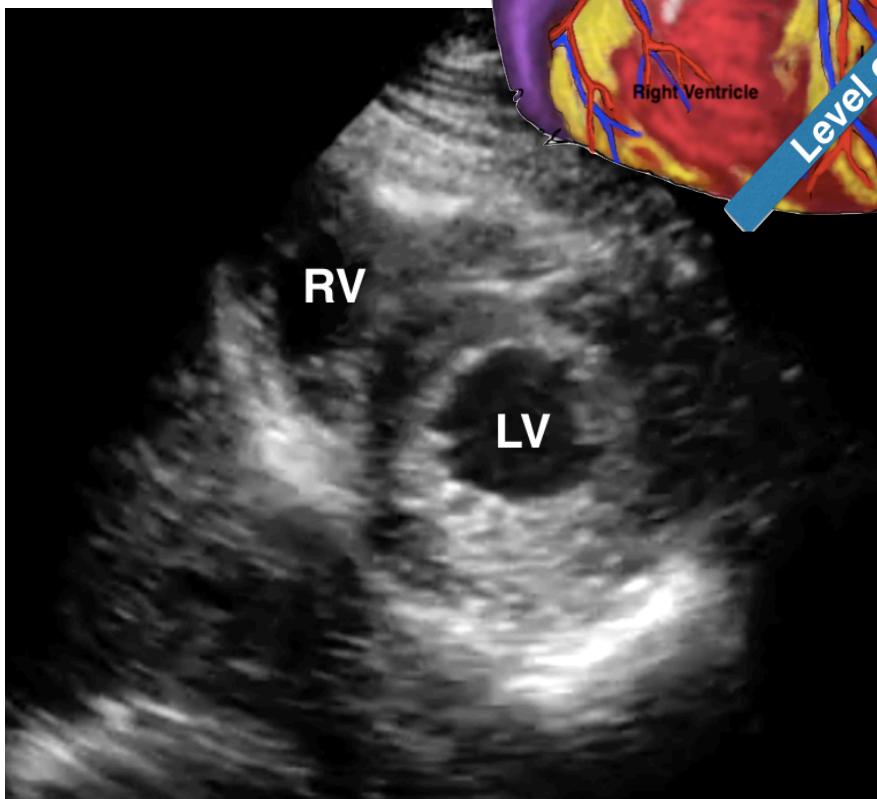
PSAX (Apical level)



2.11a To view the apical segments of the LV from PSAX, you need to tilt the probe further downward caudally.



2.10b Cut plane of apical view in PSAX.



2.11c The LV appears much smaller in this view because we cut the LV close to the apex, where its diameter is small. This view is helpful in assessing apical LVF or identifying an apical thrombus.

Apical four chambers view (A4C)

1. Patient position :

- a. Supine
- b. Left lateral decubitus
- c. Semi recumbent

2. **Depth** : start with 15 cm and then adjust accordingly until both atrium at the base of the screen and the apex of the heart at the top of the screen

3. Technique :

- a. From the initial position of PSAX view, with LV at the centre of the screen , slide the probe diagonally towards apex beat. Slide it continuously (while maintaining the LV at the centre of the screen). Until you reach the apex.
- b. When reaching the apex, tilt the probe upward 45 degree (while the probe handle go downward 45 degree).
- c. Apply firm pressure towards the apex, until you see the four chamber view.
- d. Adjust the probe slightly until you see the four chamber as bullet shape with it septum at the mid-screen.
- i. Another technique to get good A4C view is to place the probe at the level of 5th intercostal space, lateral to the midclavicular line.
- ii. The probe marker is at 3 o'clock position (patients' left shoulder).
- iii. Then points the probe footprint towards right shoulder by tilting the transducer upward (with it handle tilt downward).

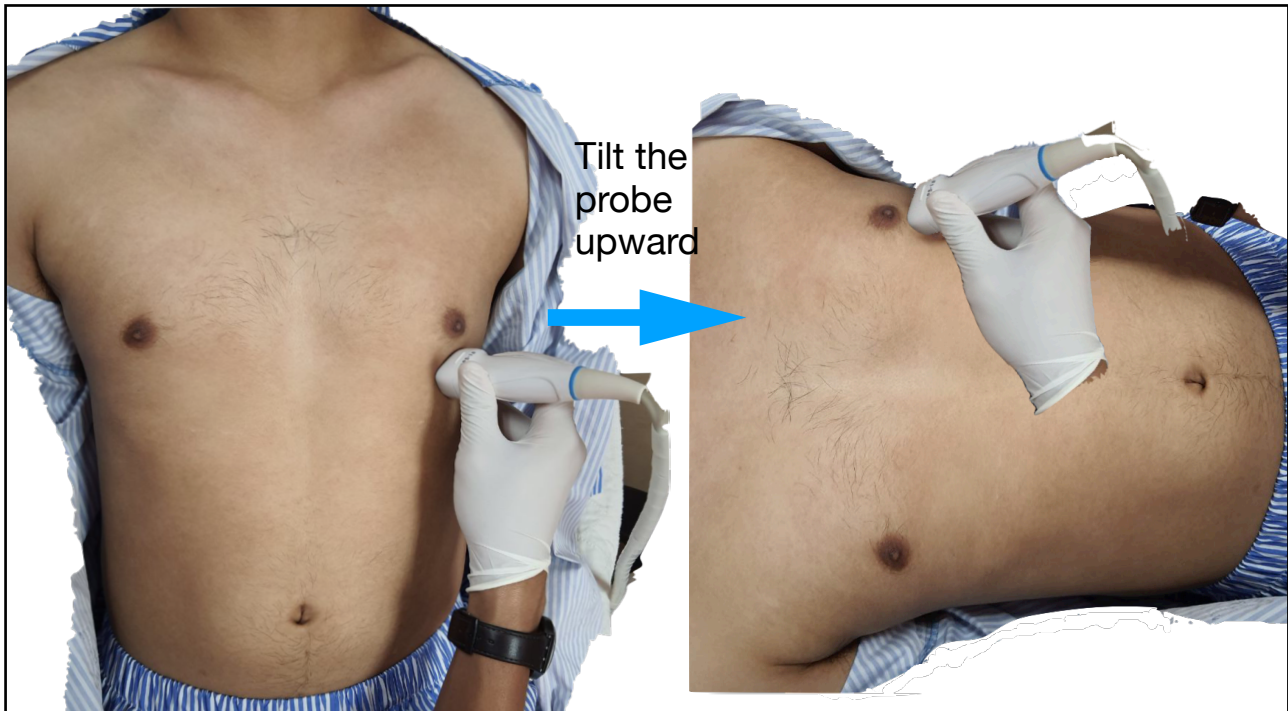
4. Structures that need to be identified in A4C view :

1. LA (Left atrium)
2. RA (Right atrium)
3. LV (left ventricle)
4. RV (Right ventricle)
5. Mitral valve
6. Tricuspid valve

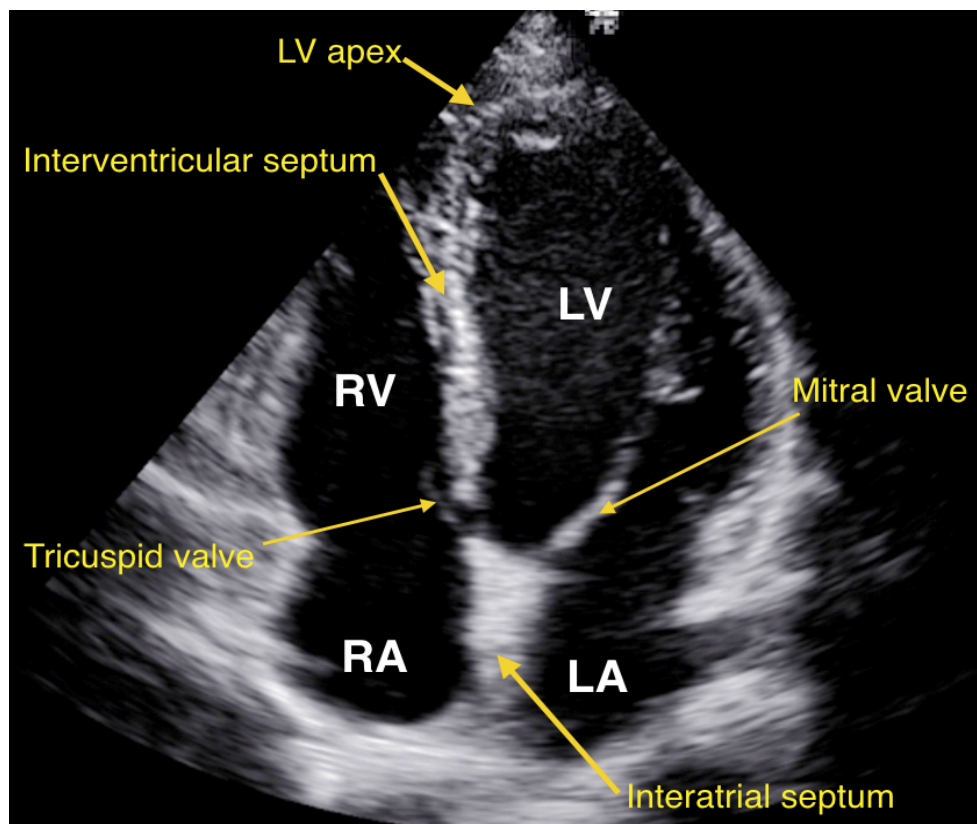
5. Abnormalities that can be detected in A4C view:

1. Eyeballing of LV function.
2. Enlarged and D shape RV (when there is high pressure in right ventricle) with a paradoxical movement of septal wall, especially in cor pulmonale. McConnell sign if present, it strongly suggests an acute cor Pulmonale e.g Pulmonary embolism.
3. Pericardial effusion with tamponade effect.
4. Intracardiac thrombus/mass.

A4C (Apical Four Chambers)



2.12a The apical window is usually found in the fifth ICS, however patient's constitution largely determines the position of the apex (e.g obesity, cardiomegaly, lung emphysema). You will be able to determine the apex position by palpating the apical impulse. In still PSAX position, slide the probe downward toward apex. Then, tilt it upwards with the footprint angulate approximately 30 degree.



2.12b The four chamber view is ideal to assess contractile function, heart chambers and valves. In normal A4C, heart should look like bullet shape and the RV looks like a sail shape with it size 1/3 of the LV.

Subcostal four chambers view (S4C)

* This window may provide the only achievable view in technically difficult patients such as those with hyperinflated lungs (e.g COPD patients), abnormal chest wall, and patients whom are mechanically ventilated.

1. Patient position :

- a. Supine

2. Depth : start with 14 cm and then adjust accordingly until the LA at the base of the screen and left liver lobe at the upper screen.

3. Technique (2 methods)

A) Use the liver as a landmark:

- I. Probe marker pointed towards the patient's right (curvilinear probe).
- II. Place the probe footprint subcostally at the midclavicular line with the probe pointed toward patient right shoulder while the transducer handle is near the umbilicus.
- III. While maintaining the same X-axis of the handle, swipe the transducer from right to left toward patients left shoulder by moving your wrist from right to left side. Until you visualize the four chambers.

B) Use xiphisternum as a landmark:

- I. The probe is placed below and slightly to the right of the xiphisternum.
- II. Slowly point the probe towards patients left shoulder, tilt the transducer upward. You might need to push the transducer slightly downwards into the abdomen in order to achieve the proper view.

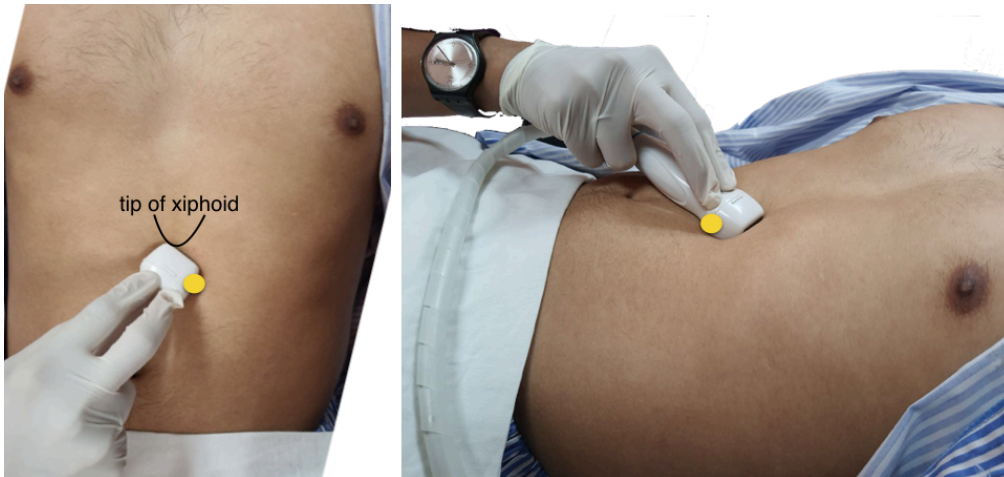
4. Structures that need to be identified in S4C view :

- I. LA (Left atrium).
- II. RA (Right atrium).
- III. LV (left ventricle).
- IV. RV (Right ventricle).
- V. Mitral valve.
- VI. Tricuspid valve.
- VII. Liver (left lobe).

5. Abnormalities that can be detected in S4C view:

- I. Eyeballing of LV function.
- II. Enlarged and D shape RV (when there is high pressure in the right ventricle) with paradoxical movement of septal wall, especially in Pulmonary Embolism.
- III. Pericardial effusion with tamponade effect.
- IV. Intracardiac thrombus/mass.

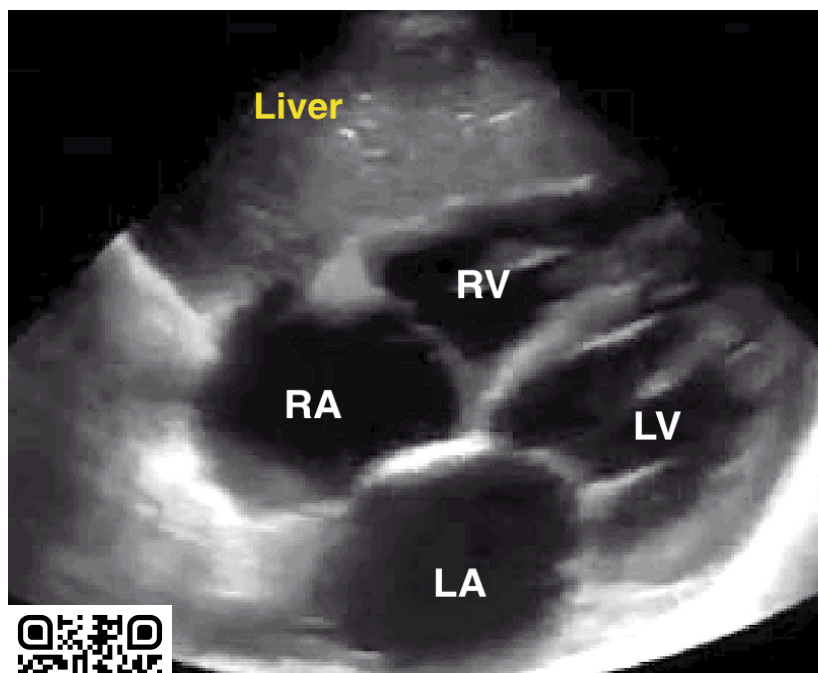
S4C (Subxiphoid Four Chambers)



2.13a The probe is placed under the xiphoid, while the footprint pointing towards left shoulder.



2.13b If using curvilinear probe without reversing the screen marker, the probe marker should be on the right side of the patient.



2.13c The four chambers in S4C view. Right ventricle located near to left lobe of the liver.

What to look in basic cardiac ultrasound

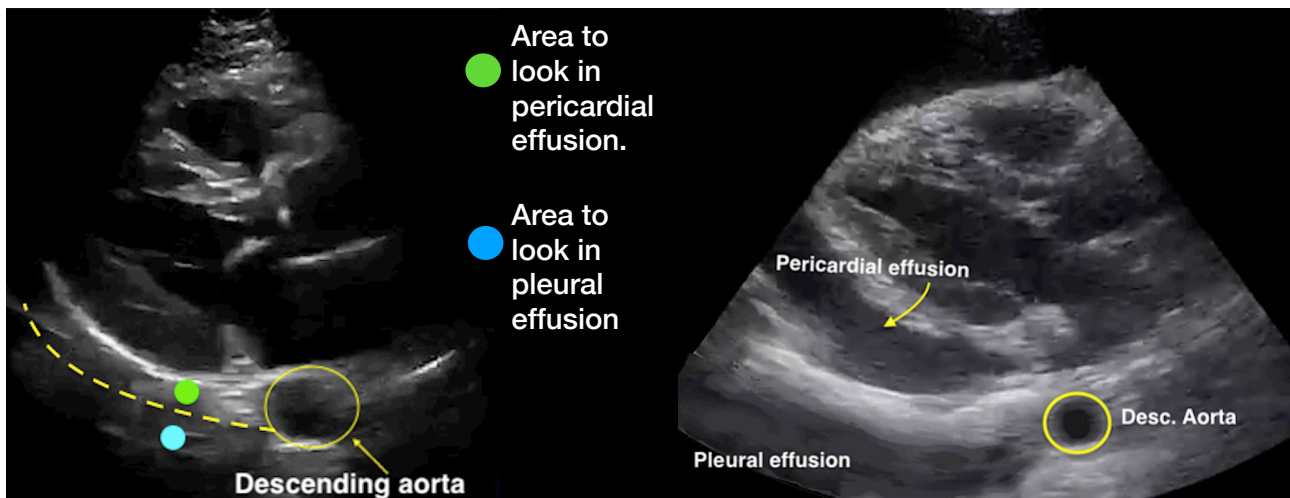
Rules :

1. Do ECHO on normal persons , see how normal heart looks like.
2. Have a rough guide on how normal heart chambers appears (e.g in four chamber views, the RV always smaller than LV (1/3 - 2/3 size of LV).
3. Interpret ECHO from outer to inner (from pericardium to intraventricular).

What to look:

1. Pericardial effusion

- Is it present?
- does it cause tamponade effect?
(RV collapsed during diastole)



2.14 PLAX is a good view to assess pericardial fluid. Descending aorta as a landmark to determine whether the fluid is from pericardial or pleural.

2. Chambers dimension

- I. PLAX view - is ratio of RV, LVOT and LA the same?
- II. PSAX view - is RV in normal crescent shape? D shape RV indicates high pressure in the right heart.
- III. Four chamber view - are the four chambers normal in size and ratio? Is LV ballooning?

3. Presence of regional wall motion abnormalities (RMWA)

- I. PLAX
- II. PSAX
- III. Four chambers view

4. Presence of intracardiac mass / clot

Important cardiac pathologies in basic cardiac ultrasound:

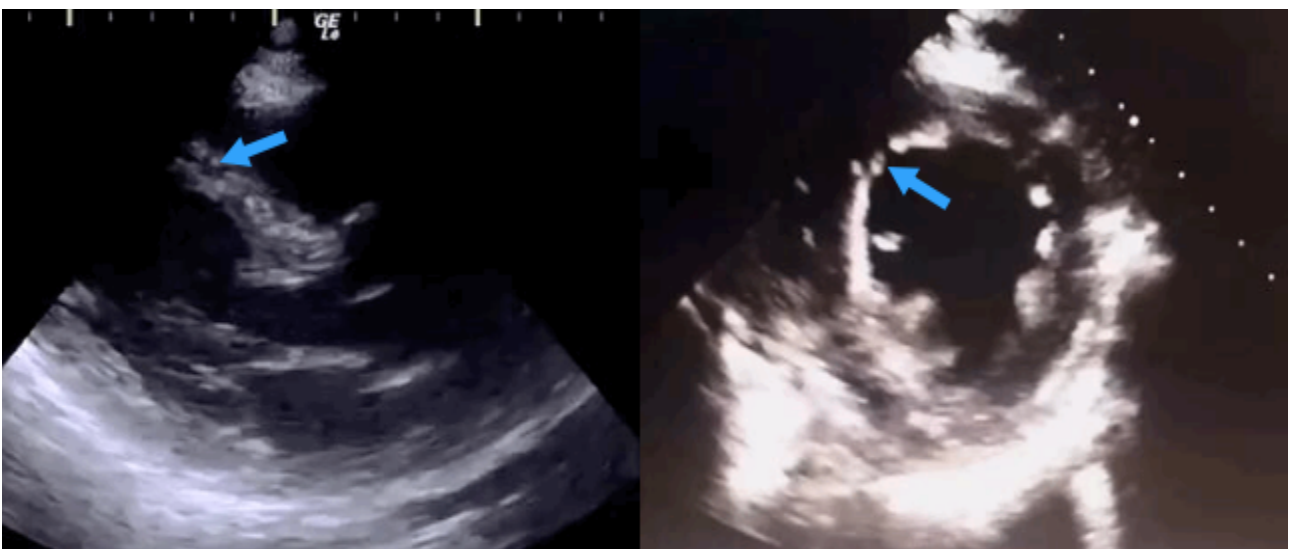
1. Myocardial infarction - assesment of regional motion abnormalities.
2. Cardiac tamponade - assesment of pericardial effusion and tamponade effect.
3. Intracardiac mass - assesment of cardiac tumour or thrombus.
4. Pulmonary embolism - assesment of acute increase in right heart pressure.

1. Myocardial infarction

Echocardiography in acute myocardial infarction is useful for identification of :

- a. RMWA (regional wall motion abnormalities).
 - absence or reduction of systolic thickening.
 - decreased motion - hypokinetic, akinetic or dyskinetic.
- b. Complication of myocardial infarction.
 - e.g ruptures papillary muscle.
- c. AMI mimics i.e Dissecting Aortic Root Aneurysm.
 - e.g typical chest pain with inferior STEMI on ECG but actually it is an acute Stanford type A aortic dissection.

RMWA (in anteroseptal myocardial infarction)

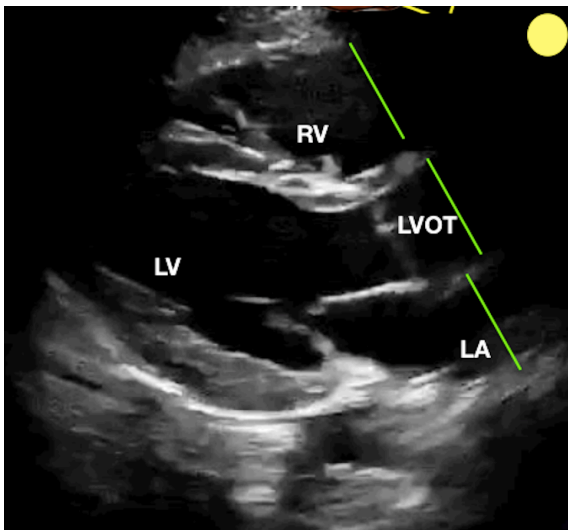


2.15a (vid) PLAX -hypokinesia at anteroseptal wall.

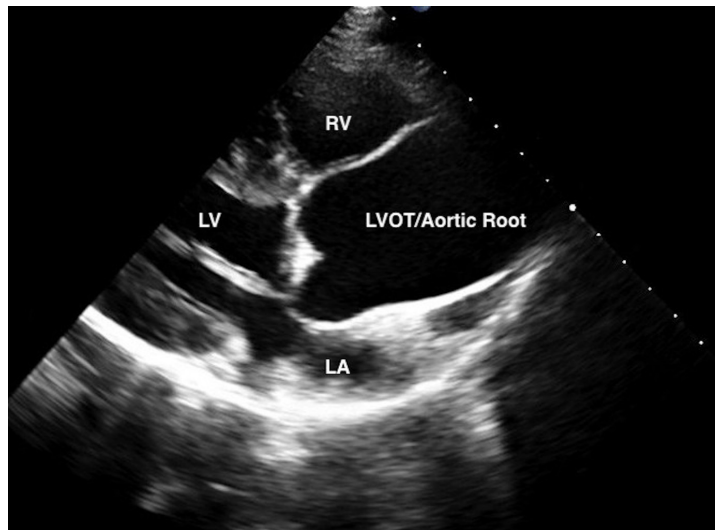


2.15b (vid) PSAX -hypokinesia at anteroseptal wall.

AMI mimics i.e Dissecting Aortic Root Aneurysm

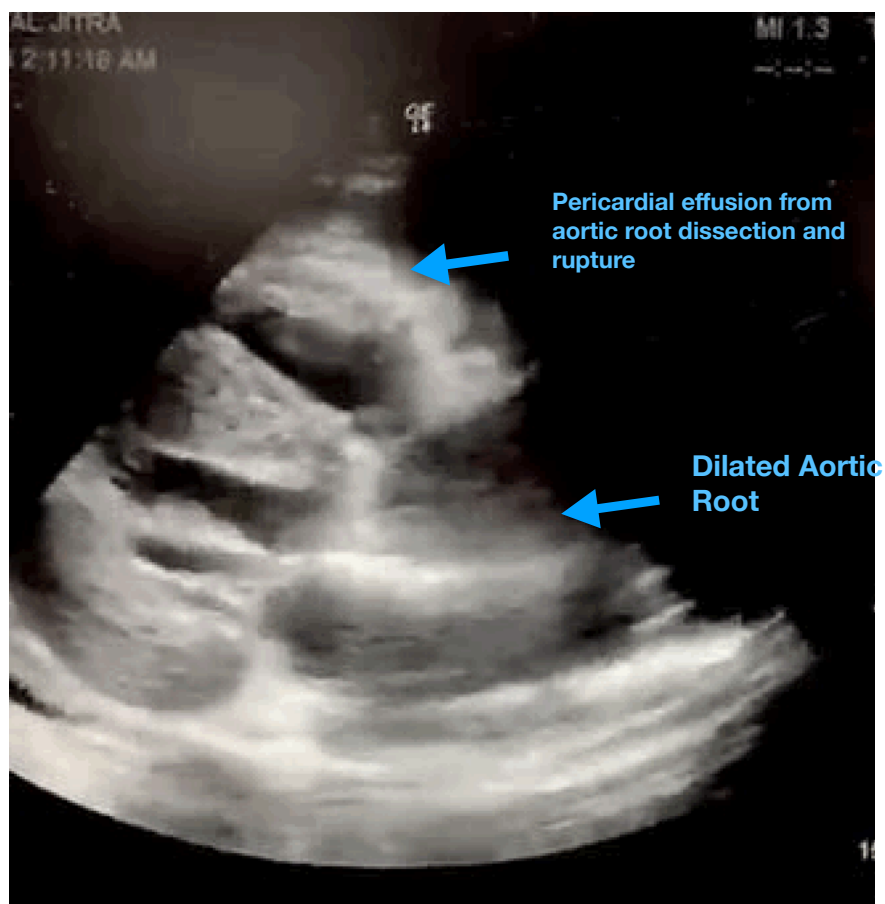


2.16a



2.16b

2.16a-b Normally the size of RV, LVOT and LA are almost the same (green line in the 2.16a figure of PLAX view). In figure 2.16b, the aortic root is enlarged compressing the LA. Aortic root diameter more than 4 cm suggestive of an Aortic root aneurysm.



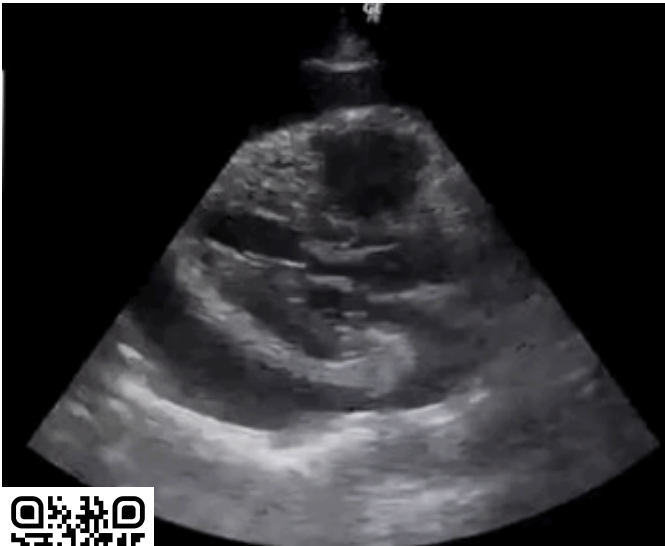
2.16c (vid) Dilated and ruptured aortic root with pericardial effusion

2. Cardiac Tamponade

- Echo is part of RUSH protocol (Rapid Ultrasound in Shock). It is important to look for cardiac tamponade as a cause of an obstructive shock.
- Evidences of cardiac tamponade in echocardiography are :

Pericardial effusion **with** :

- A. RA collapse during systole (early sign).
- B. Plethoric IVC.
- C. RV collapse during diastole.
- D. LV collapse (late sign).



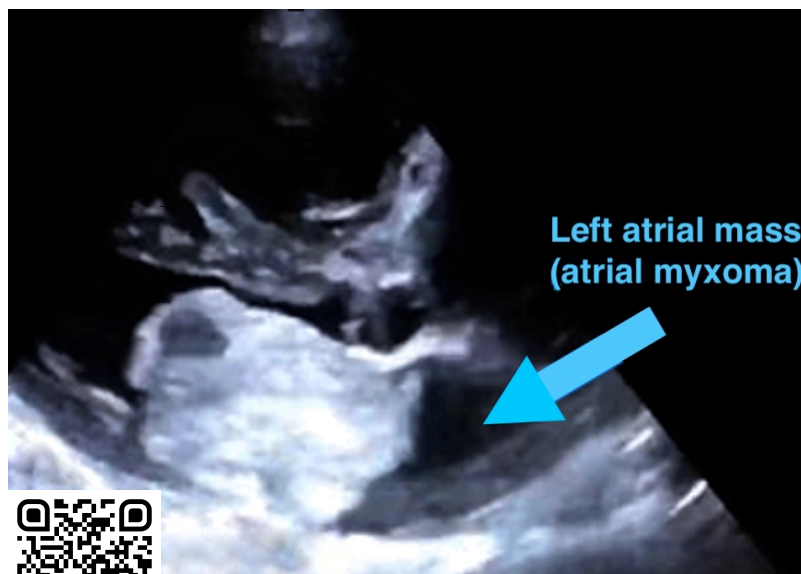
2.17a (vid) Dancing heart in cardiac tamponade.



2.17b (vid) Plethoric IVC with poor variability.

3. Intracardiac Mass

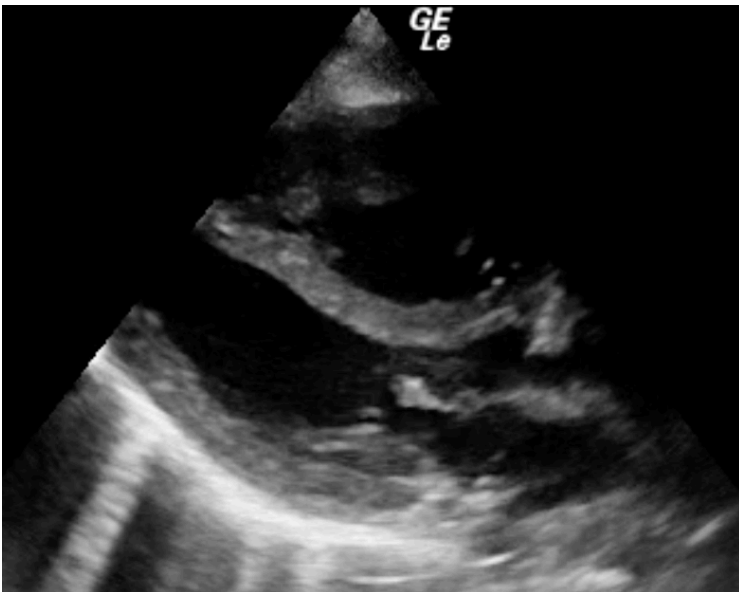
- Look for :
- a) Thrombus (usually mobile and doesn't have stalk).
 - in right heart - can cause Pulmonary embolism.
 - in left heart - can cause stroke / limb ischaemia.
 - b) Intracardiac mass esp atrial myxoma
 - might causing an obstructive shock.



2.18 Left atrial mass seen in PLAX view (video)

4. Pulmonary Embolism

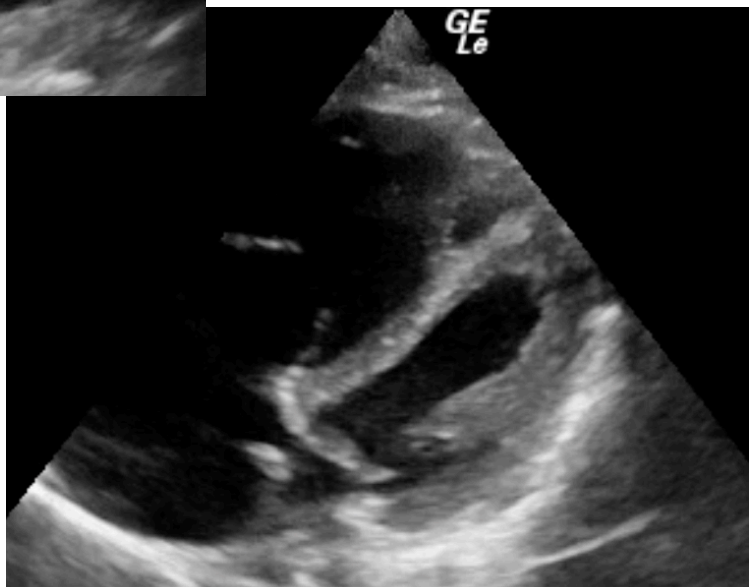
- One of the causes of obstructive shock and acute dyspnea with clear lung fields is a pulmonary embolism.
- What you see during cardiac ultrasound in patient with pulmonary embolism, is the effects of the heart due to sudden increase in right heart pressure.
- CTPA is the gold standard to confirm Pulmonary embolism.
- Echocardiography findings in PE (due to acute blockage in pulmonary artery):
 - a) RV dilatation - D shape RV wall.
 - b) Paradoxical septal wall motion (LV septal wall collapse in diastole).
 - c) McConnell's sign (hypokinesia/akinesia of the mid-free right ventricular wall with preserved apical contractility).
 - d) Evidence of intracardiac thrombus.
 - e) Trouser's sign (dilated pulmonary artery).
 - f) Embolus seen in pulmonary artery (especially in saddle PE), is a strong evidence of PE in echo.
 - g) Plethoric IVC.



2.19a (vid) Dilated round shape RV in PLAX view. LV septal collapsed during diastole.



2.19b (vid) Dilated both RA and RV in apical four chamber view. The right heart is massive and tense causing mass effect by compressing left ventricle.



Lung Ultrasound

Lung Ultrasound

Objectives

1. Learn the appropriate techniques and scanning areas.
2. Understand the basic aspect of lung ultrasound and its interpretation based on direct visualization of structures and artifacts.
3. Able to use ultrasound in the evaluation of dyspneic patients.

Technical requirements

A. Probe :

- i) Linear ii) Curvilinear



3.1a Linear - best to view superficial structures.



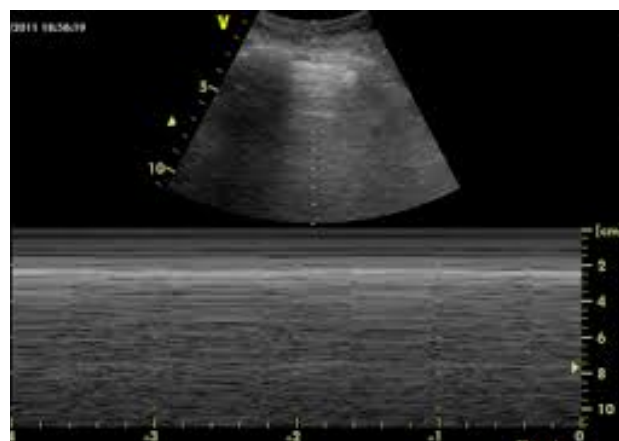
3.1b Curvilinear - best to view deeper structures.

B. Mode :

- i) B mode ii) M. Mode



3.2a View in B mode.



3.2b View in M mode (motion display of the ultrasound wave along the chosen line).

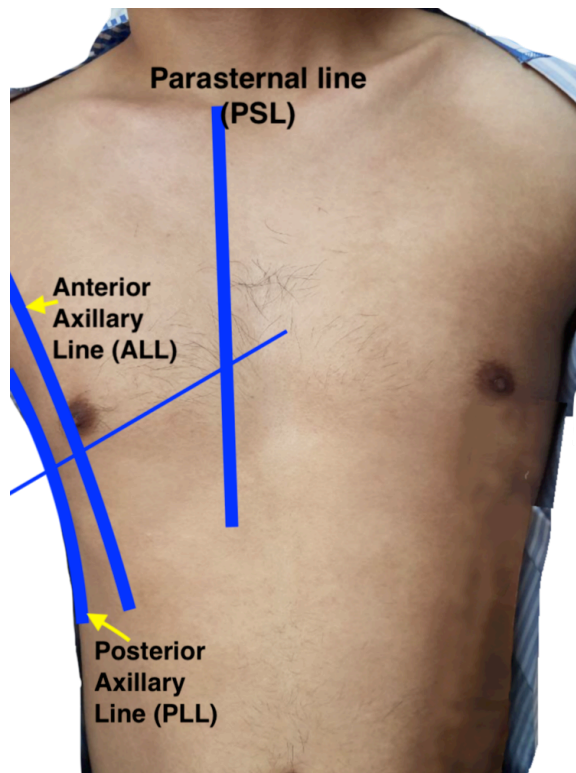
C. Patient Position :

- i) Supine (standard) ii) Semi recumbent iii) Prone

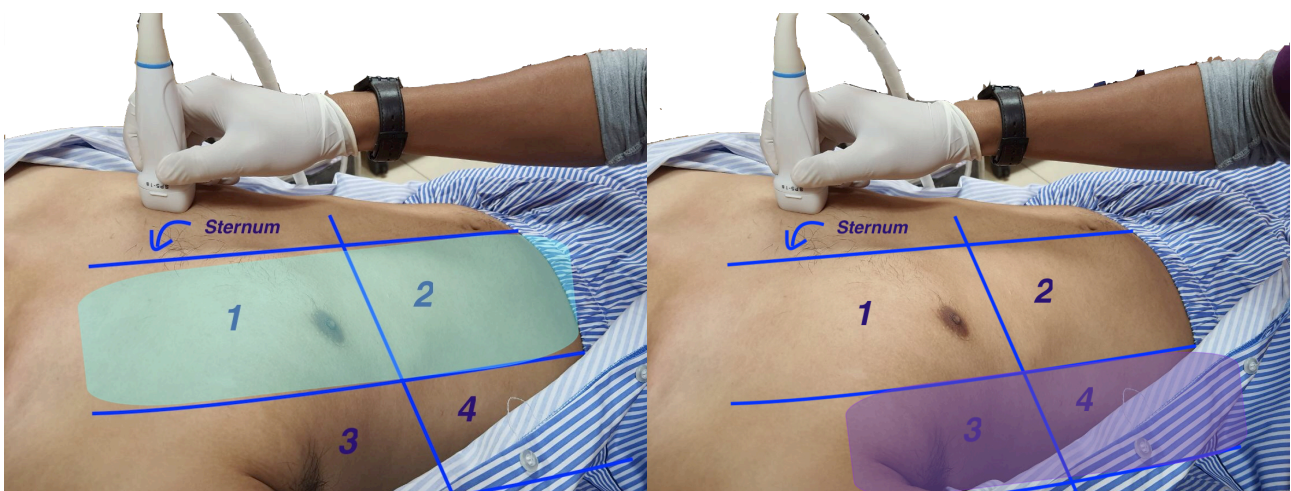
Ultrasound technique

A. Identify scan area

- Anterior Zones 1 & 2 - between PSL and ALL (best to see pneumothorax).
- Lateral Zones 3 & 4 - best to see effusions and consolidations .
- Posterior Zones 5 & 6 - just behind the PLL (best to see effusions and consolidations).



3.3a The imaginary lines that divide the lungs into 6 zones.



3.3 a,b Common lung scanning area (anterior and lateral zone)

B. Lung ultrasound views :

- a. Longitudinal view b. Oblique view

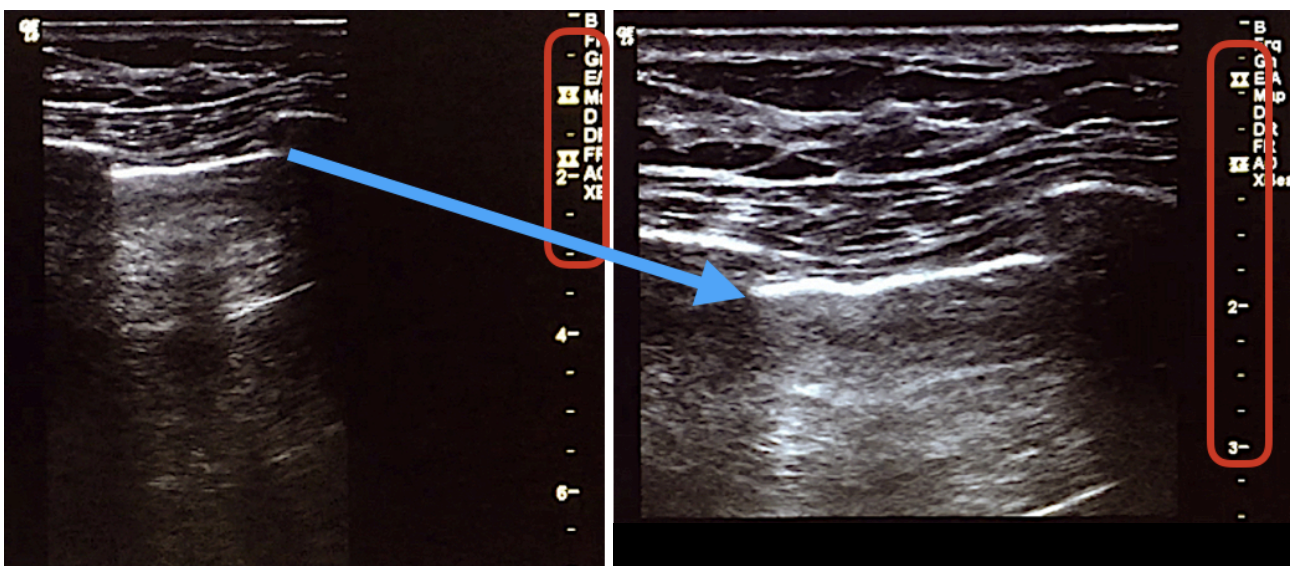


3.4a Longitudinal view, where two ribs can be visualized.



3.4b Oblique view, where two ribs are out of view.

- C. **Position the structures of interest** : to the middle of the screen by adjusting the depth (zoom) and sliding the probe until the image is at the centre.

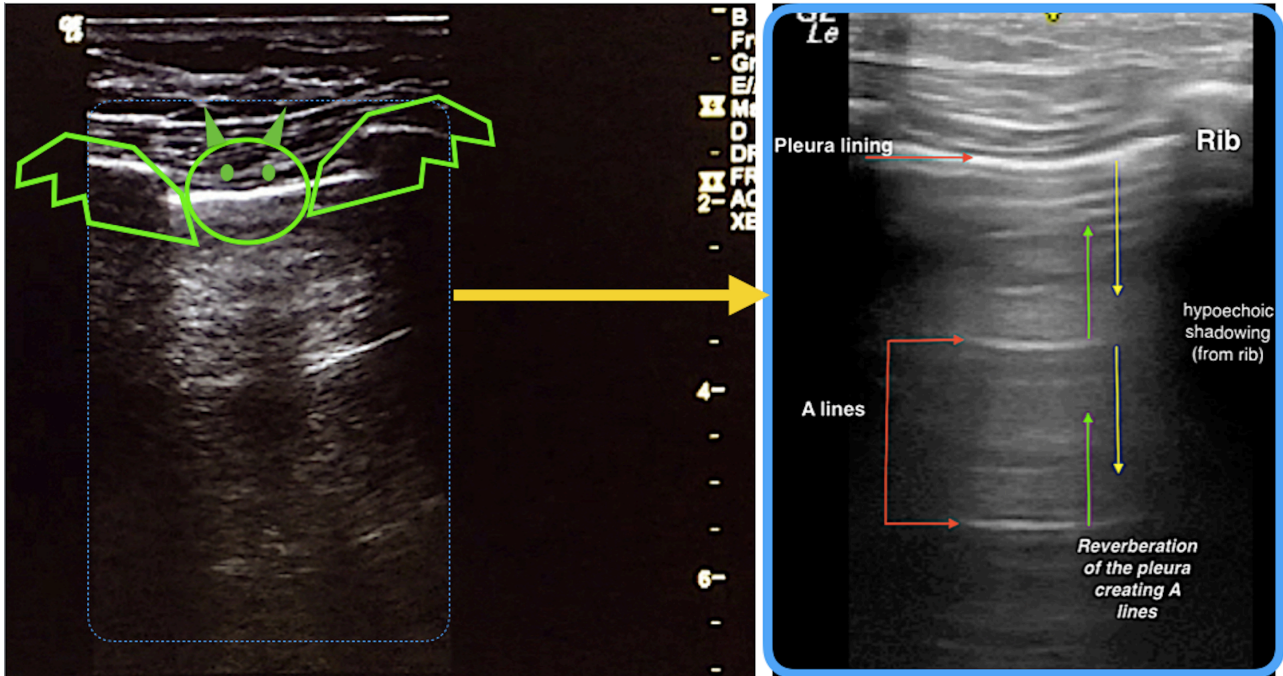


3.5a,b Longitudinal view, when the depth is reduced (zoom in).

What to look in Lung Ultrasound

Step 1

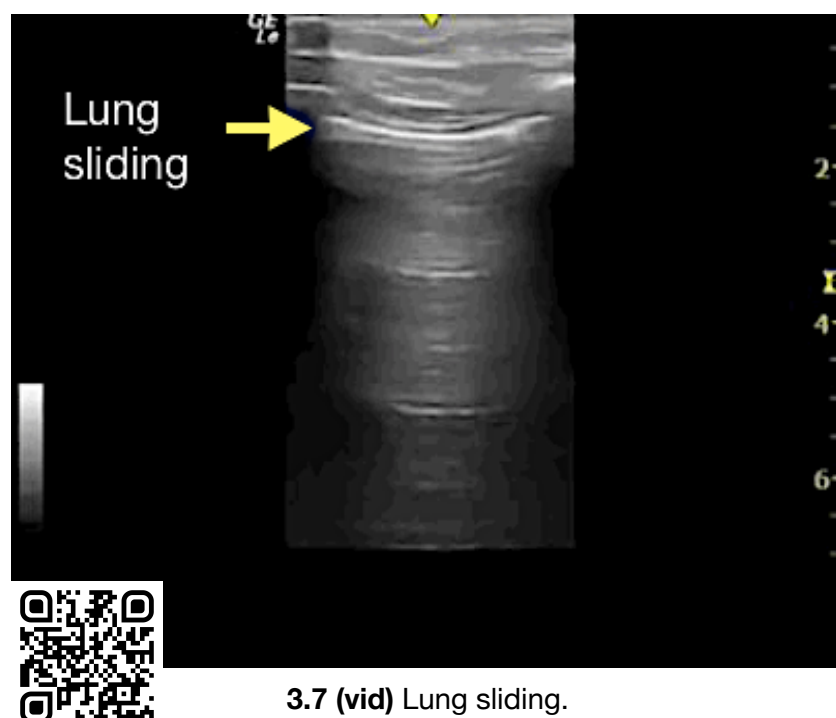
- Do longitudinal view to view the “Bat sign”.
- Identify the 2 ribs - make sure the two ribs are parallel to each other.



3.6 a,b The 'Bat sign' which the body of the bat is the pleura and the ribs as wings.

Step 2

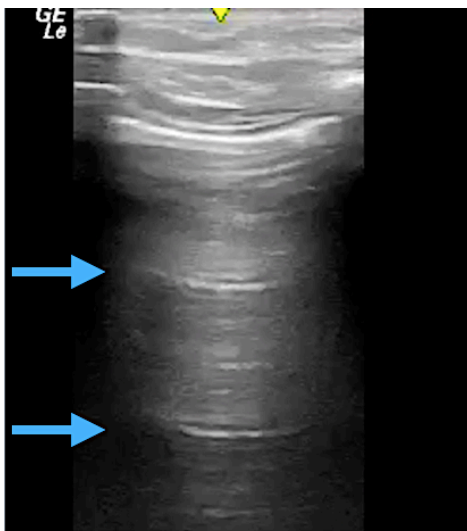
- Identify the pleura (between the two ribs).
- Identify lung sliding (back and forth movement of parietal and visceral pleura sliding on each other with respiration).



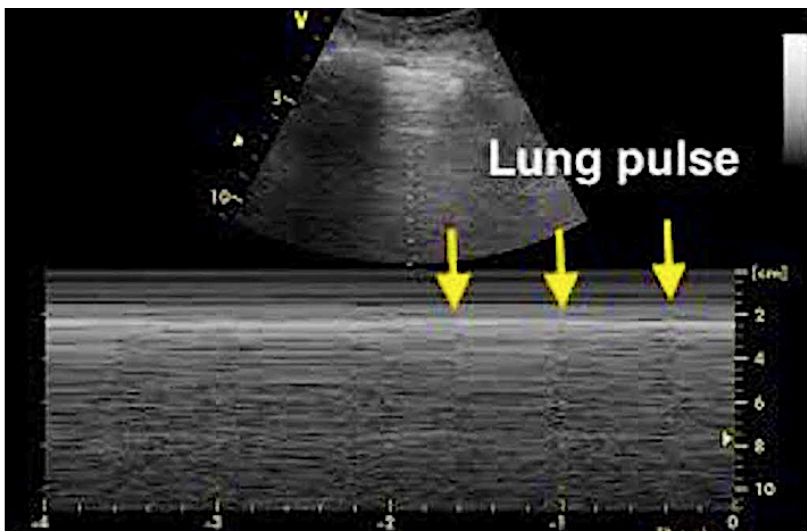
3.7 (vid) Lung sliding.

Step 3

- Look for A lines below the pleura line.
- Change to M mode - look for sea-shore appearance, look for lung pulse.



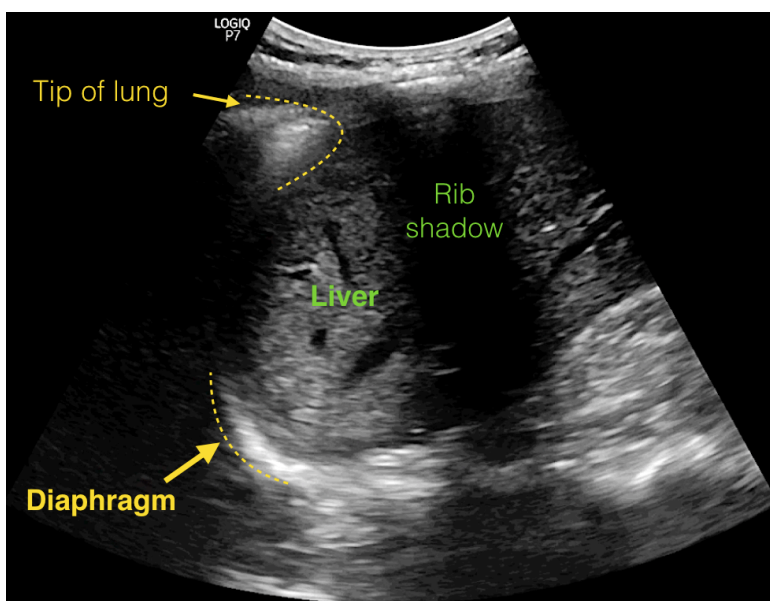
3.8a B mode view demonstrate A line between the ribs



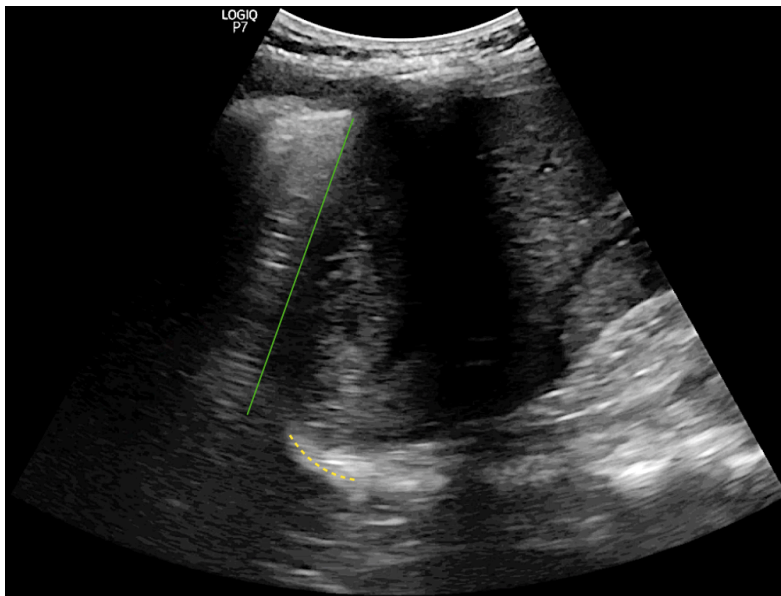
3.8b M mode view of sea shore appearance when the line sets on the pleura (between the ribs)

Step 4

- Scan the lateral zone (Region 3 and 4) until you reach the diaphragm and liver.
- Look for curtain sign (seen as the pleural line with a 'curtain' covering the structures beneath, moving caudally and obscuring the liver/spleen during inspiration)
- Absent curtain sign —> usually due to presence of fluid or consolidation at the lung bases (pleural effusion, haemothorax or consolidated lung).



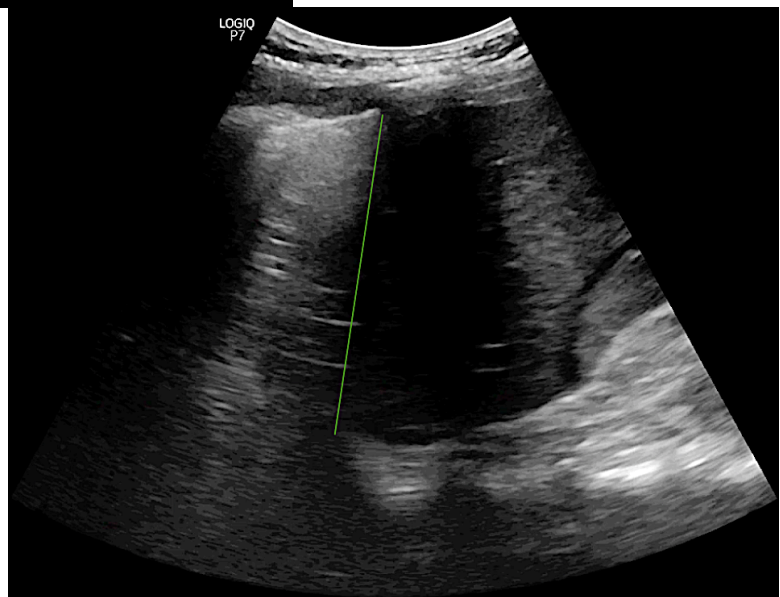
3.9a Tip of lung seen above the diaphragm during expiration.



3.9b Lung moves caudally obscuring the diaphragm and liver (green line). Seen as partially drawn 'curtain'.



3.9c The lung is seen fully covered the diaphragm (green line) during full inspiration.



Step 5

- Identify for any abnormality.
- Common abnormalities in lung ultrasound.

B mode:

- > 3 B lines in one view.
- Shred sign / subpleural consolidation.
- Lung hepatization (looks like liver above the diaphragm within lung fields).
- Lung point (area in between normal sliding pleura and absent of pleural sliding).
- Spine sign (able to visualize spinal vertebrae above the diaphragm)

M mode

- Stratosphere.
- Sinusoidal pattern.

Common lung pathologies

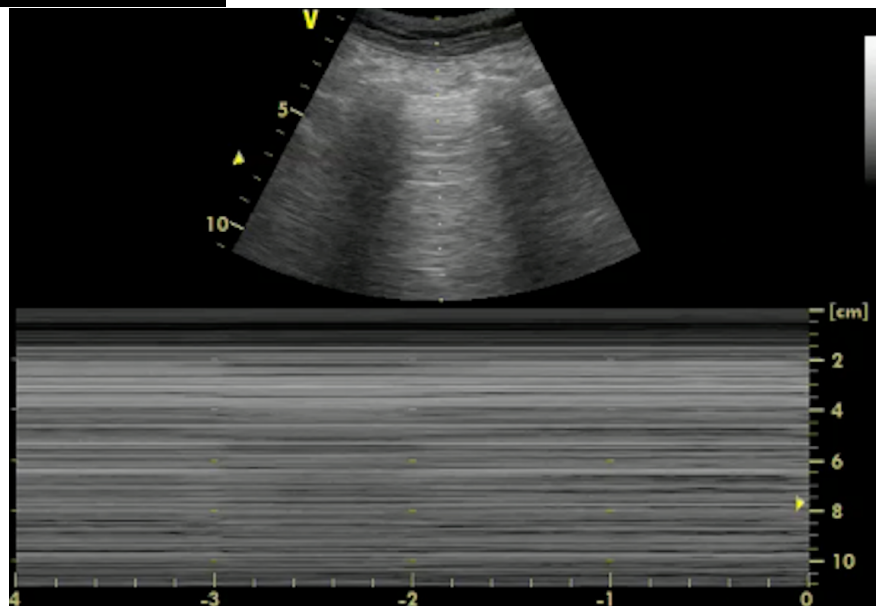
1	Pneumothorax
Pleura sliding	Absent sliding sign
A line	Present
M mode	<ul style="list-style-type: none"> - Barcode/stratosphere - Absent lung pulse
Extra	<ul style="list-style-type: none"> - No B line - Lung point presence (+/-) - Absent lung pulse



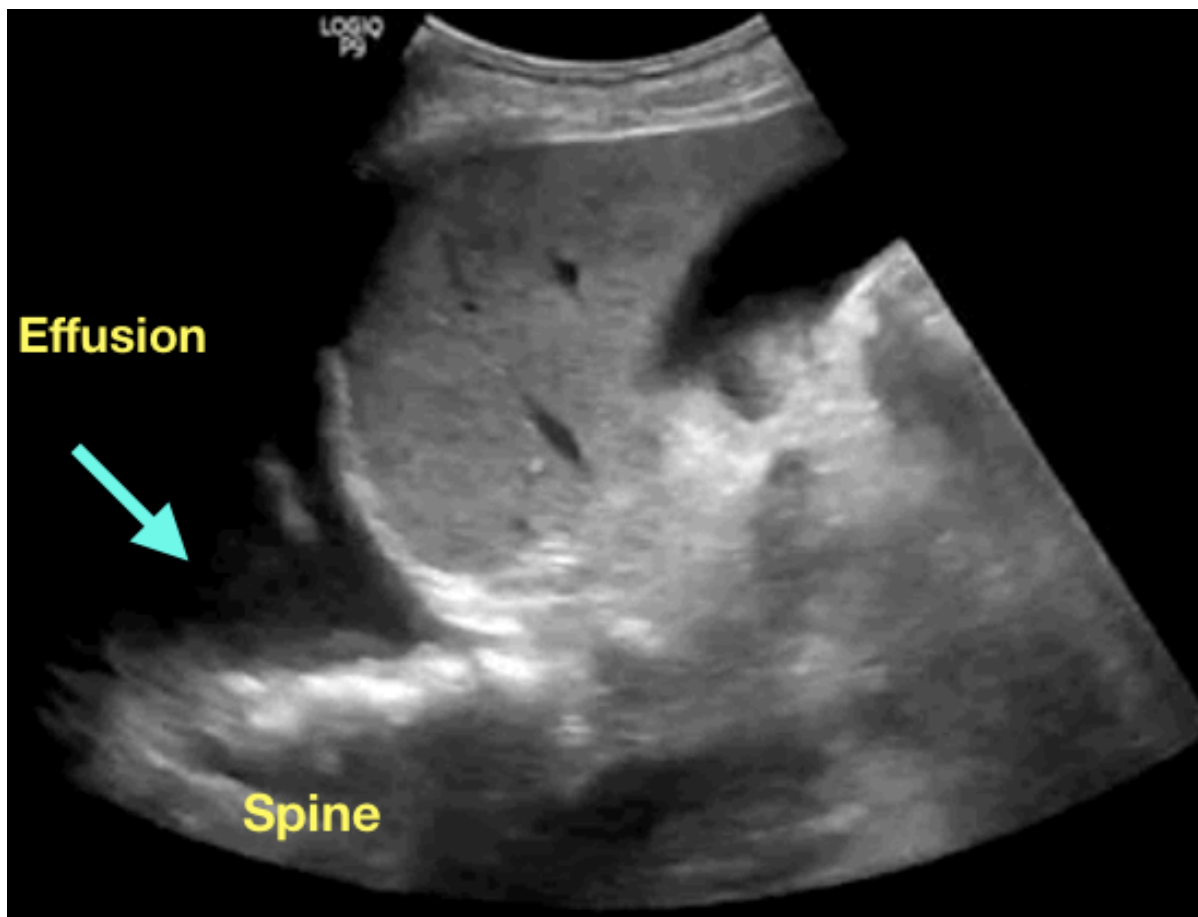
3.10a (vid) Lung point where the visceral and parietal pleura are separated in pneumothorax.



3.10b M mode view of stratosphere appearance when the line sets on the pleura.

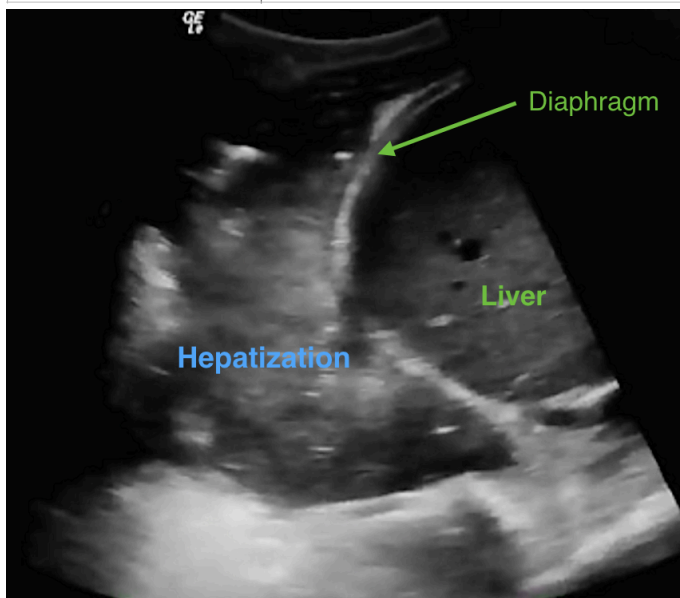


2	Pleural effusions / Haemothorax
Pleura sliding	Absent of sliding sign
A line	Absent
M mode	Sinusoidal pattern
Extra	<ul style="list-style-type: none"> - Floating lungs (able to see the lung as a solid organ in lung ultrasound). - Spine sign present above the diaphragm. - Seaweed sign (in chronic pleural effusion). - Hypoechoic above the diaphragm or Isoechoic in haemothorax (old blood). - Absent curtain sign.



3.11 (vid) Pleural effusion, seen as hypoechoic or anechoic structure above the diaphragm. Spine sign can be seen cranial to diaphragm. Noted that curtain sign is absent.

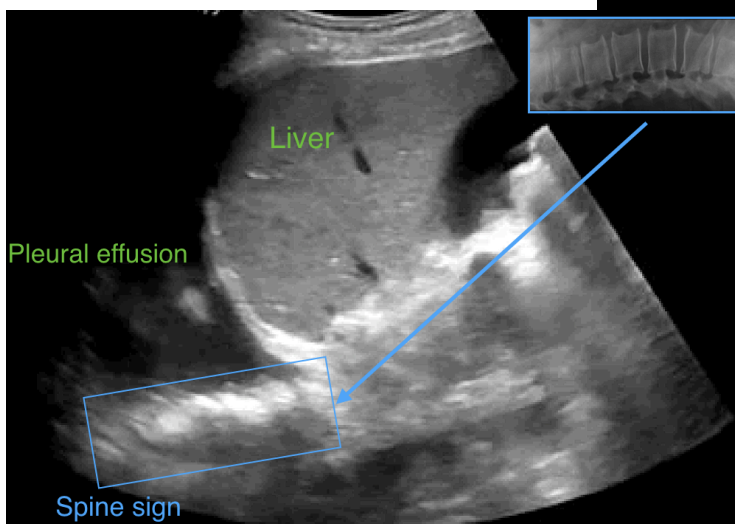
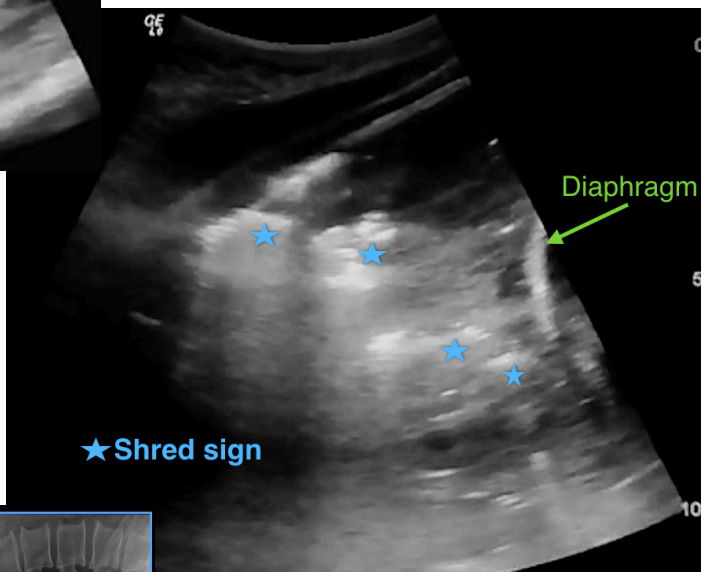
3	Pneumonia
Pleura sliding	<ul style="list-style-type: none"> - Sliding sign present. - Irregular pleura line +/-
A line	Mostly absent
M mode	Seashore appearance
Extra	<ul style="list-style-type: none"> - Ununiformed scattered sites/unilateral sites of B-lines. - Shred sign (irregularities below the pleura, looks like shredded paper). - Lung hepatization (consolidation/liver like texture above diaphragm). - Absent curtain sign +/- (esp in lower lobe consolidation).



3.12a Lung hepatization, alteration of lung tissue that resembles liver. Noted that the echogenicity of pathologic lung is almost the same as liver.

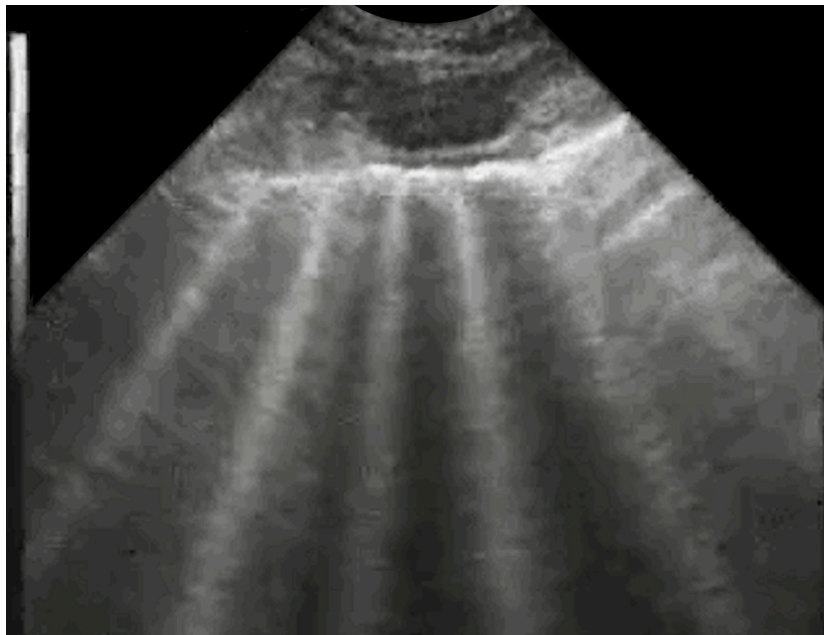


3.12b The irregular junction between consolidated and aerated lung is called *shred sign*. These features resembles shredded paper.



3.12c Spine sign is indirect indicator of the presence of pleural effusion or hemothorax. It represents the visualization of thoracic spine (which usually not seen in normal lung ultrasound).

4	Pulmonary oedema
Pleura sliding	Present
A line	Present BUT B-lines >> A-lines
M mode	Seashore appearance
Extra	<ul style="list-style-type: none"> - Generalised B-lines which are bilateral, uniformed and originating from pleural lines (scan from base to apical of the lung). - Bilateral pleural effusion might be present. - Absent shred sign or hepatization. - Curtain sign preserved unless pleural effusion present.



3.13 Presences of more than 3 B lines indicate wet interlobular septa which suggestive of Pulmonary oedema (cardiogenic or non-cardiogenic)

5	Pulmonary Embolism
Pleura sliding	Present
A line	Present
M mode	Seashore appearance
Extra	<p>Same as normal lung ultrasound</p> <ul style="list-style-type: none"> * please proceed with ECHO and IVC if patient dyspneic with clear lung fields * PE is diagnosis of exclusion in unexplained hypoxia in normal lung ultrasound.

FAST

**(Focused Assessment
with Sonography for
Trauma)**

FAST scan

(Focused Assessment with Sonography for Trauma)

Objectives

1. Familiarize with technical performance, interpretation and understand the limitation of FAST scan.
2. Understand the concepts on how to perform the FAST and EFAST examinations properly, emphasizing the techniques used and the appropriate ultrasound windows.
3. Able to detect free fluid in the peritoneal, pleural and pericardial spaces (FAST) and also to detect free air/fluid in thoracic cavities (EFAST).

Technical requirement

1. Probe selection

- a) Curvilinear : Preferred probe for excellent intraabdominal views.
- b) Phased array : Useful for intercostal views and cardiac views.
- c) Linear : Only used for paediatric patients with thinner abdominal wall and less subcutaneous fat.

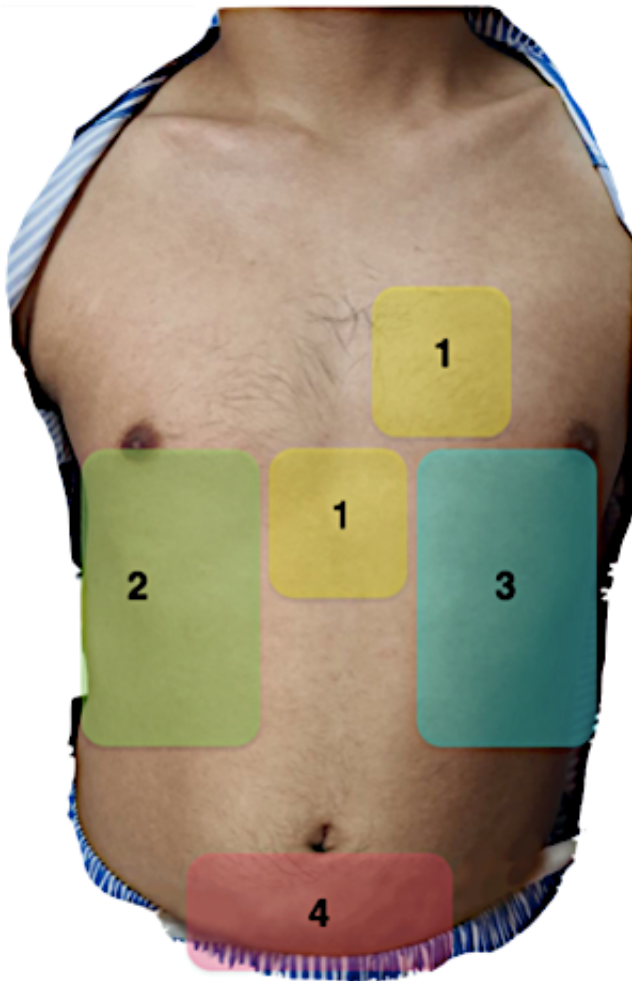
2. Patient position

- a) Supine : For optimum view.
- b) Semi recumbent : For patient whom unable to lie flat.

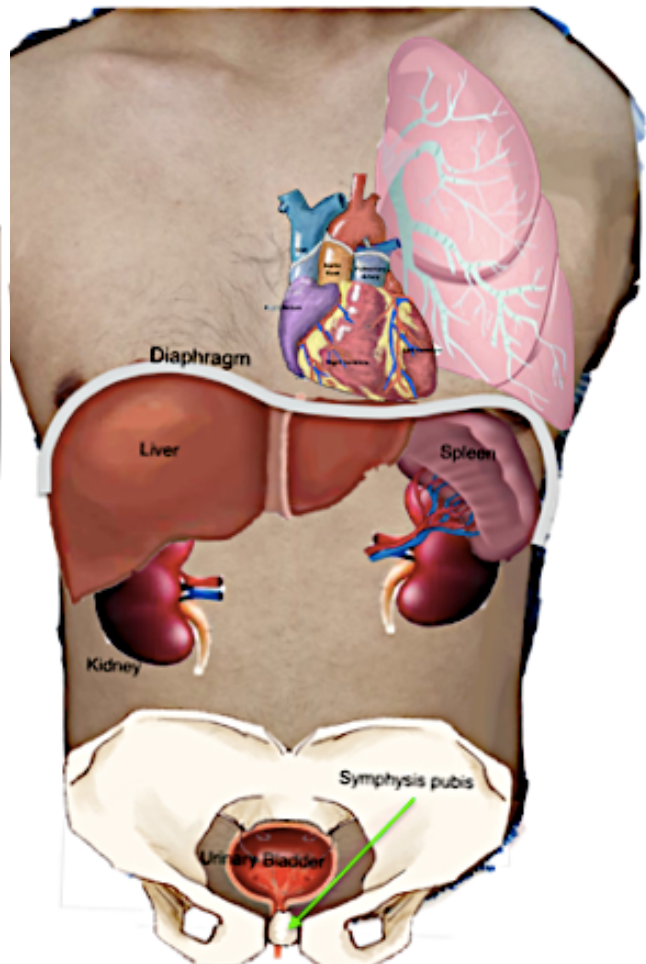
3. General settings:

- a) Select exam - Choose 'Abdominal' preset setting.
- b) Depth setting
 - i) For adult start with 15 cm depth , and adjust accordingly.
 - ii) For paediatric patient, start with 12 cm depth and adjust accordingly.
- c) Start with Auto-gain , later adjust near-far gain accordingly.

Anatomy and areas for FAST scan



4.1a The four potential spaces that are sequentially examined for the accumulation of free fluid.



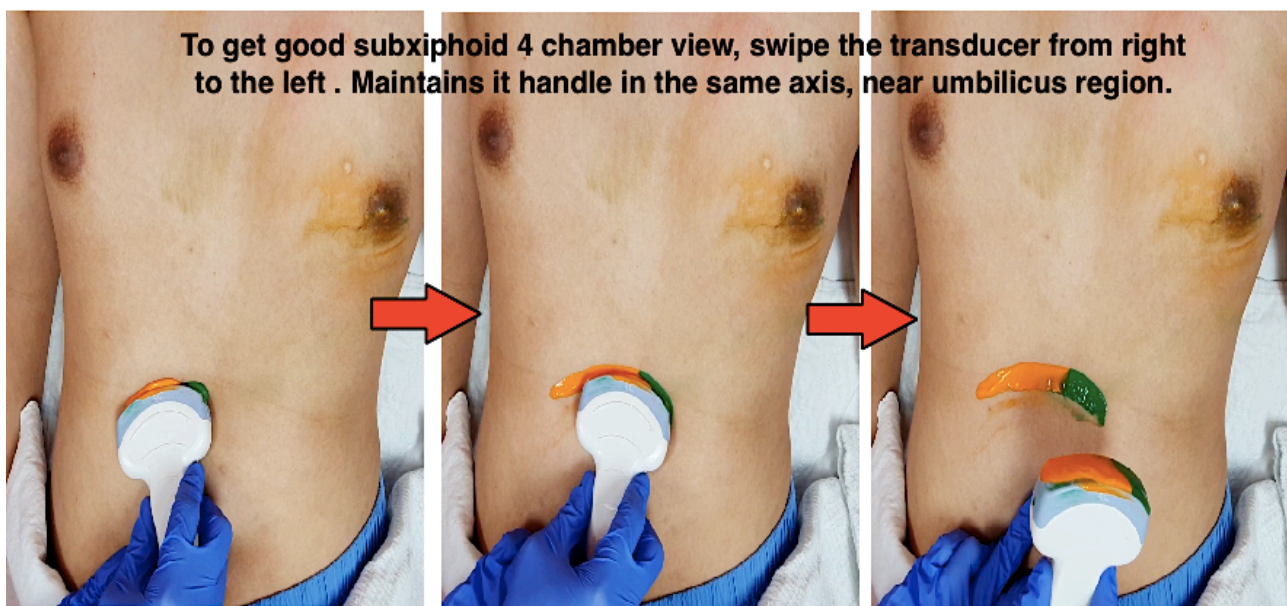
4.1b Organs location and its correlation with views in EFAST.

Views :

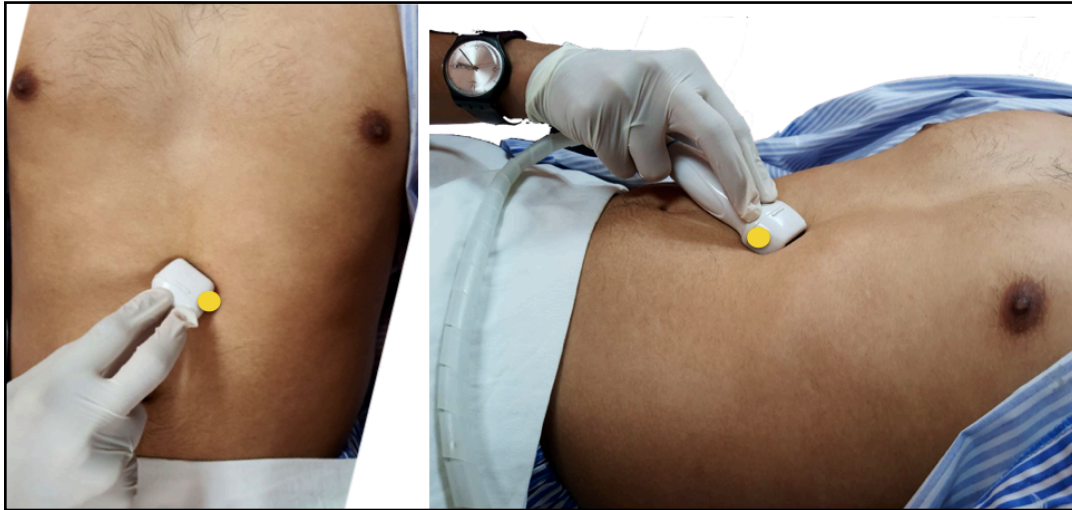
1. Pericardial views - To assess pericardial effusion
 - a) Preferred view is subxiphoid
 - b) Parasternal long axis can be use if patient has distended abdomen/difficult to view in subxiphoid
2. Right Upper Quadrant views (RUQ)- To look for intraabdominal free fluid
3. Left Upper Quadrant views (LUQ) - To look for intraabdominal free fluid
4. Suprapubic views - To look for intraabdominal/pelvic free fluid

1. Pericardial view

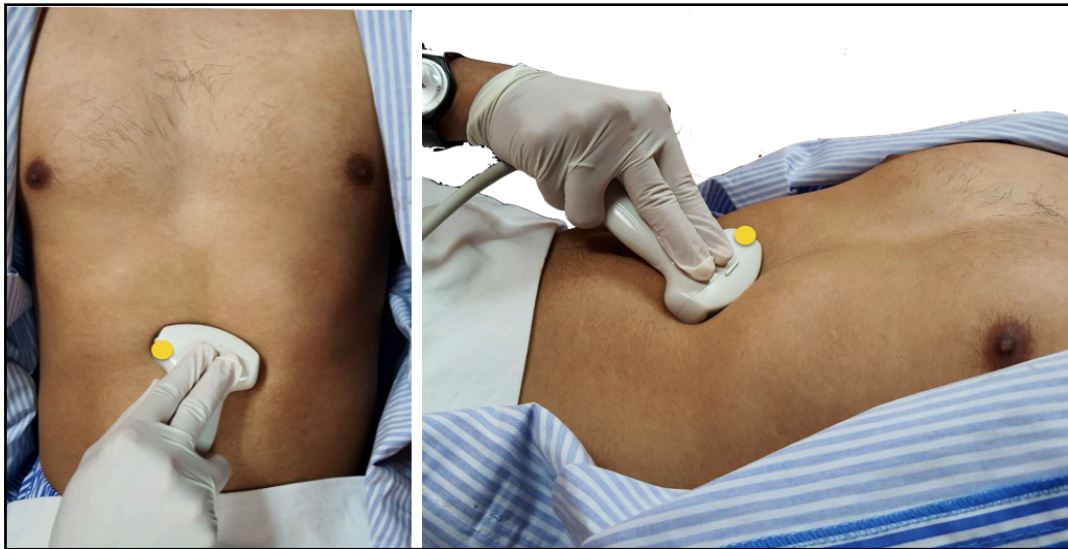
- a) Commonly referred to as subcostal or subxiphoid view.
- b) Good view to inspect for the evidence of pericardial effusion.
- c) If the patient is experiencing significant abdominal pain or distended abdomen/obese, consider switching to PLAX view (parasternal long axis)
- d) Technique :
 - I. Use the liver as a landmark.
 - II. If using phased array probe, the pointer is on the patients' left. When using curvilinear probe, the pointer is on the patients' right.
 - III. Place the probe slightly to the right of xiphoid process.
 - IV. When left lobe of the liver is visualize, swipe the probe slightly to the left side until you visualize the heart.
 - V. The right heart is always near to the liver (regardless of the image orientation).



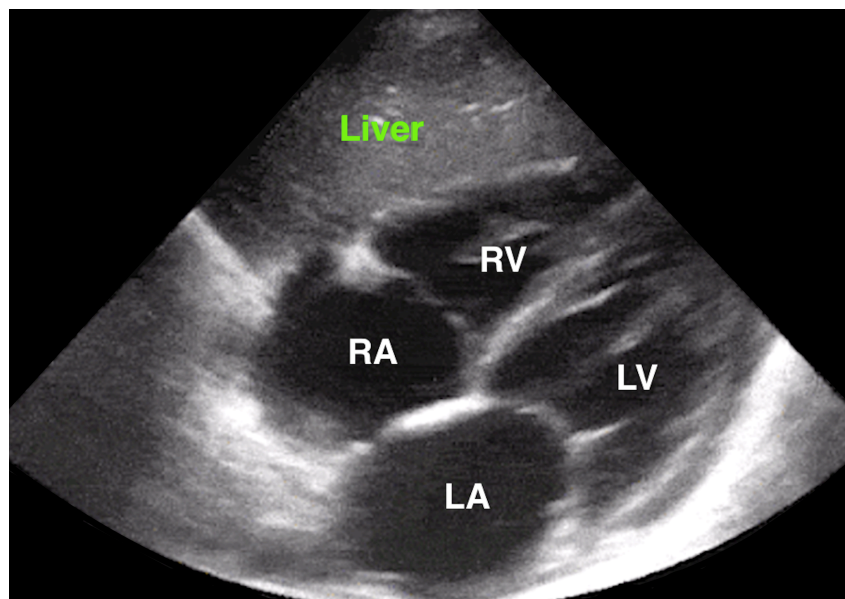
4.2 Technique to get subxiphoid four chamber view using curvilinear probe.



4.3a Phased array probe location in viewing subxiphoid four chamber. Noticed the probe is angulated at 45 degree.



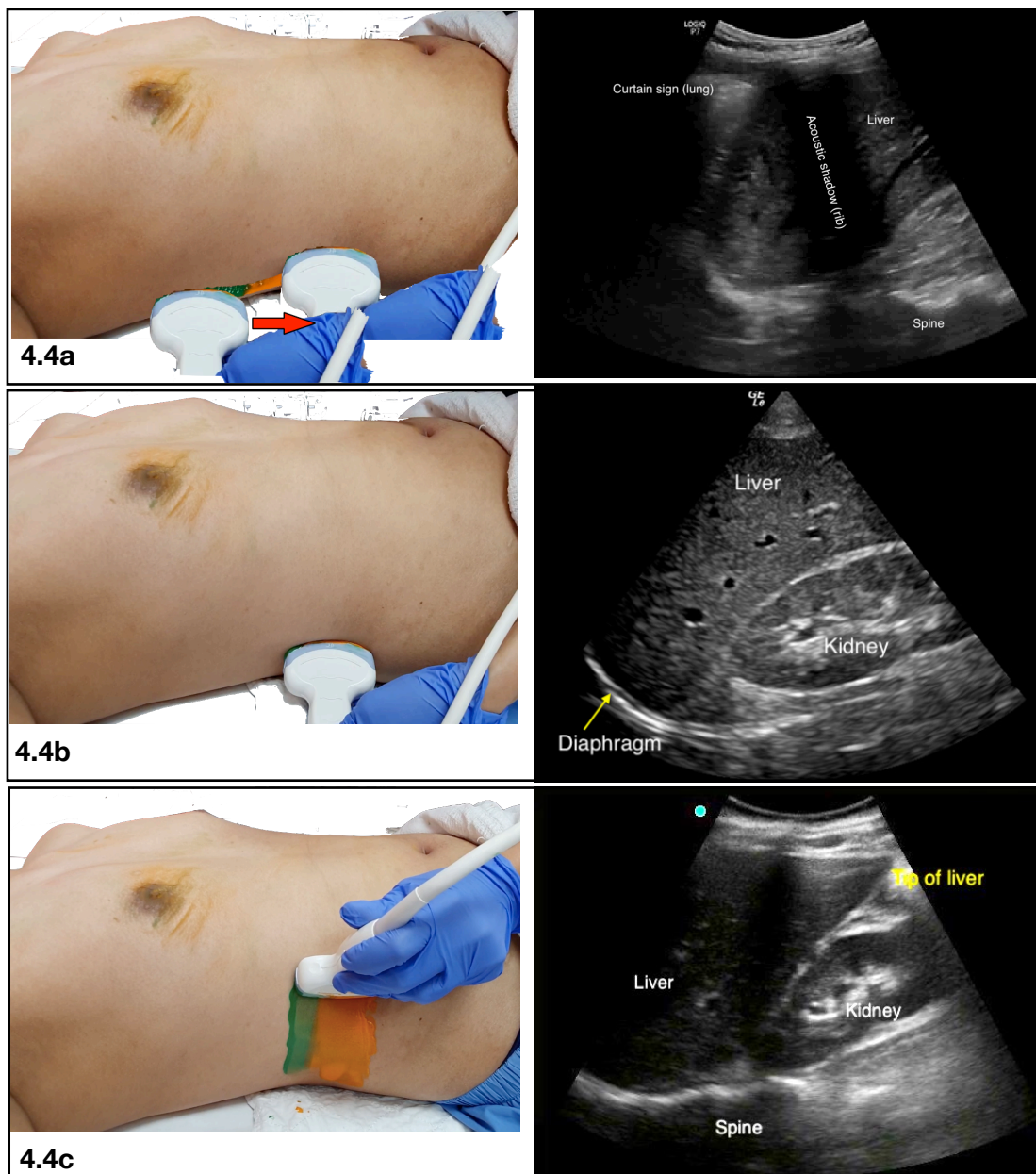
4.3b Curvilinear probe location in viewing subxiphoid four chamber.



4.3c Subxiphoid four chamber view, right heart (RA and RV) in relation to the liver.

2. Right Upper Quadrant

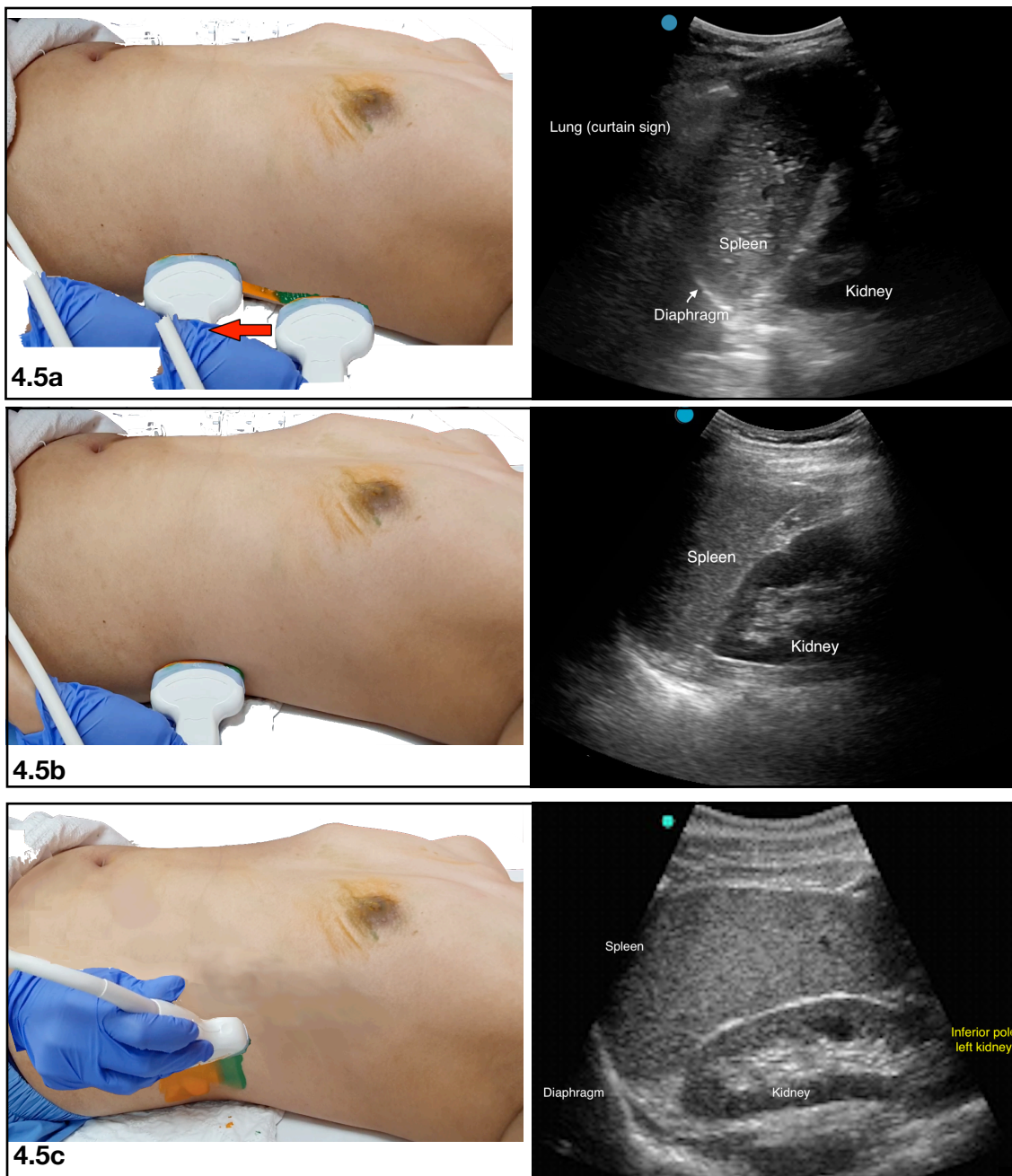
- a) RUQ is the most sensitive region for free fluid.
- b) RUQ view can be divided into 3 zones :
 - I. Above/below the diaphragm.
 - II. Morrison's pouch (hepatorenal region).
 - III. Right paracolic gutter (tip of liver and inferior pole of the kidney).
- c) Technique :
 1. Place the probe approximately at the level of 5th intercostal space, midaxillary line. With the marker pointing cranially.
 2. Slide the probe downward until you see the curtain sign. Absent curtain sign with present of spine sign indicates there is free fluid in the thorax.
 3. From that position, slide further down until you see the Morrison's pouch. Look for evidence of free fluid in between the liver and the kidney.
 4. This view is completed by sliding the probe downward and anteriorly to see the inferior pole of the kidney and tip of the liver. This is a sensitive area to see any free fluid.



4.4a-c Techniques and views for RUQ.

3. Left Upper Quadrant

- a) LUQ is less sensitive to view for free fluid than RUQ.
- b) LUQ views can be divided into 3 zones :
 - I. Above/below the diaphragm.
 - II. Splenorenal region.
 - III. Left paracolic gutter - Tip of spleen and inferior pole of the kidney.
- c) Technique :
 - 1. The probe is placed approximately over the left 4th intercostal space, posterior to mid axillary line. The marker again pointing cranially.
 - 2. Slide downwards until you see the curtain sign.
 - 3. The probe then is rotated slightly towards anteriorly (with the marker still pointing cranially).
 - 4. The view is completed by sliding the probe downward to observe the inferior pole of the kidney.



4. Suprapubic

- a) The suprapubic view is the last view to perform in eFAST.
- b) Theoretically, this is the most dependent peritoneal space in supine position.
- c) Pelvic view can be divided into 2 views:
 - I. Longitudinal view (Long axis*)
 - II. Transverse view (Short axis*)

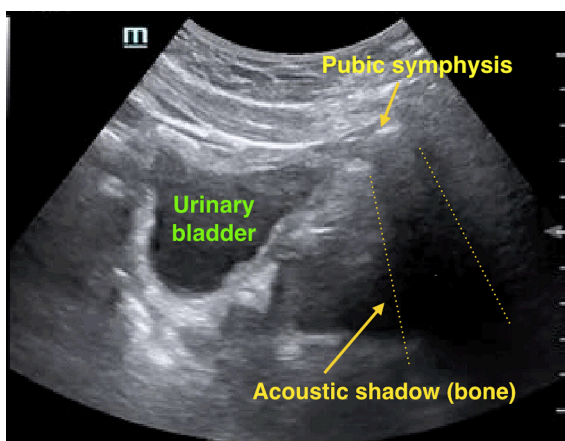
* in relation to the urinary bladder
- d) Technique :
 1. Start with longitudinal view. Place the probe vertically with the marker pointing cranially and the lower end of the probe is resting on the pubic symphysis.
 2. Identify the pubic symphysis (hyperechoic line with posterior shadowing). The urinary bladder is almost always behind the pubic symphysis.
 3. Tilt the probe side to side to assess any free fluid collection. Usually free fluid might accumulate behind the bladder or between Pouch of Douglas (in female).
 4. To get to transverse view, rotate the probe anti-clockwise 90 degree from the original position of longitudinal view.
 5. The probe marker should be on patient's right (for transverse view). Then tilt up and down to assess any fluid collection.



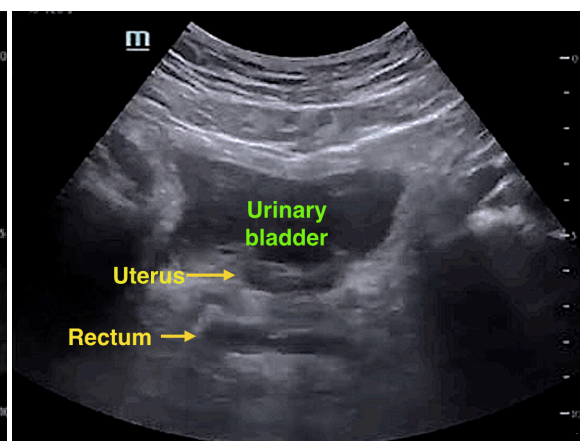
4.6a-b Probe position for suprapubic long axis.



4.6c Probe position for suprapubic short axis.



4.7a Suprapubic long axis view.



4.7b Suprapubic short axis view.

Indications of eFAST

The indications for performing an eFAST (extended FAST means FAST scan with lung ultrasound) are:

1. Blunt trauma to thorax / abdomen / pelvis.
2. Penetrating trauma.
3. Unexplained hypotension in trauma.
4. Trauma in pregnancy (plus O&G ultrasound TRO abruptio placenta).

Limitations and pitfalls

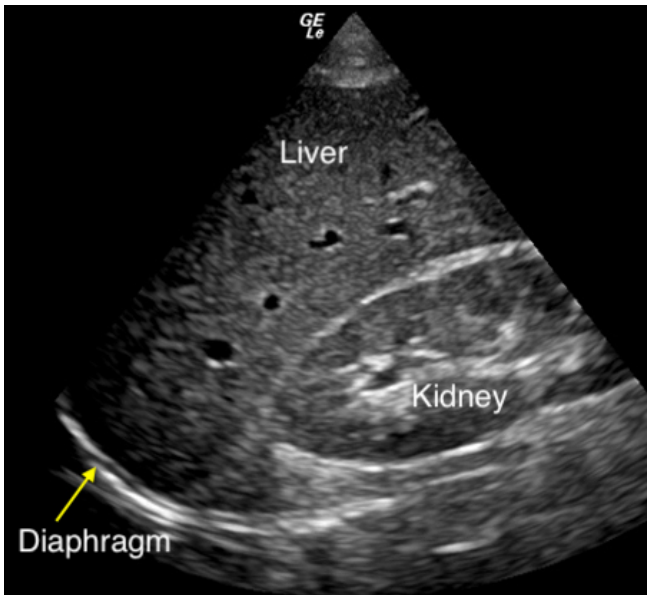
Limitations :

1. Obesity (limits assessment due to poor window and fat tissue).
2. Subcutaneous emphysema (unable to visualize below the emphysema).
3. Patient with perforated viscus (presence of large area of A lines in the abdomen).
4. Retroperitoneal bleeding is hard to detect and not always possible. Negative EFAST in the presence of unexplained hypotension in trauma patient may suggest retroperitoneal bleeding.
5. The biggest limitation is an operator who is not able to perform good standard views and lack of knowledge in identifying anatomical structures in ultrasound.

Pitfalls:

1. Epicardial fat pads, pericardial cyst and nearby blood vessels have been mistakenly identified as effusion/free fluid.
2. Pre-existing ascites/pleural effusion or pericardial effusions due to medical condition.
3. Seminal vesicles mistaken as free fluid in suprapubic ultrasound in male patient.

RUQ view

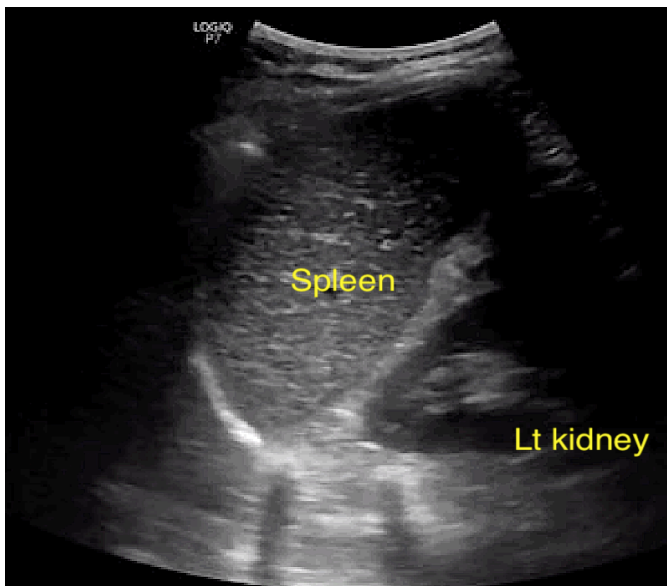


4.8a Normal RUQ view.

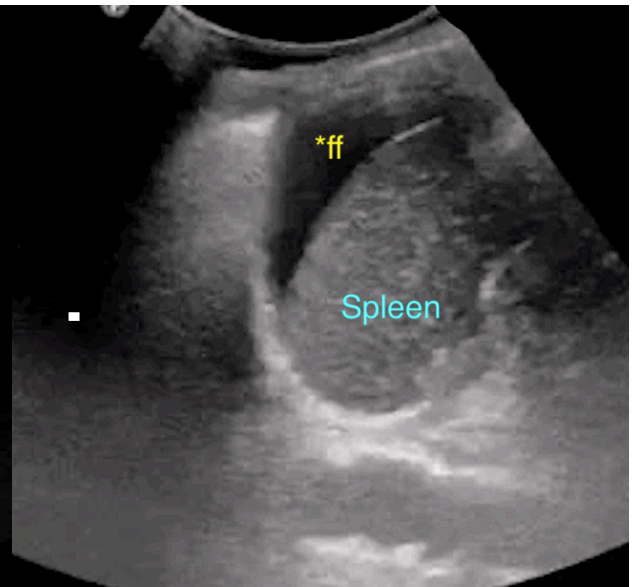


4.8b Free fluid in RUQ (positive FAST).

LUQ view

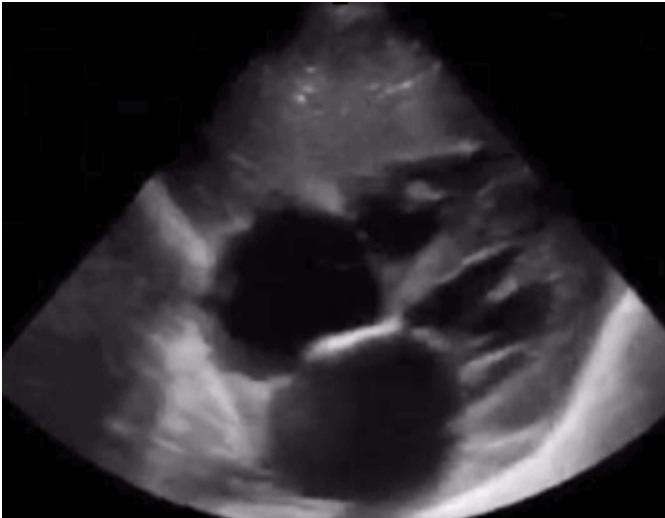


4.9a Normal LUQ view.



4.9b Free fluid in LUQ. Fluid is seen around tip and over top of spleen (less often in between spleen and kidney as opposed to RUQ).

Pericardial View

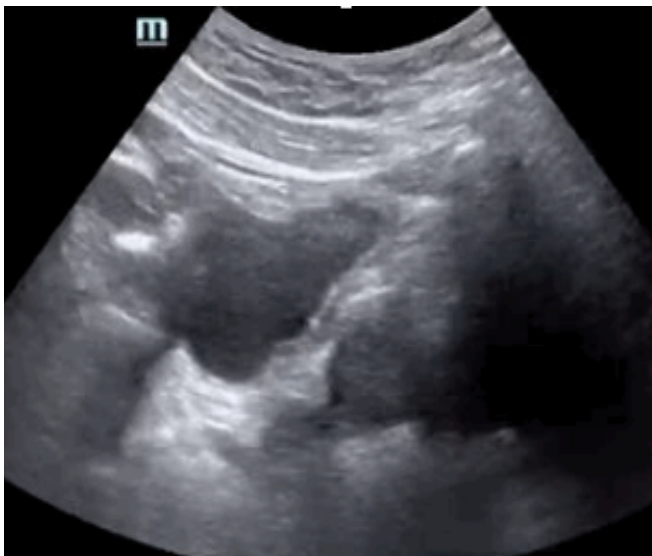


4.10a Normal Subxiphoid four chamber view (S4C).

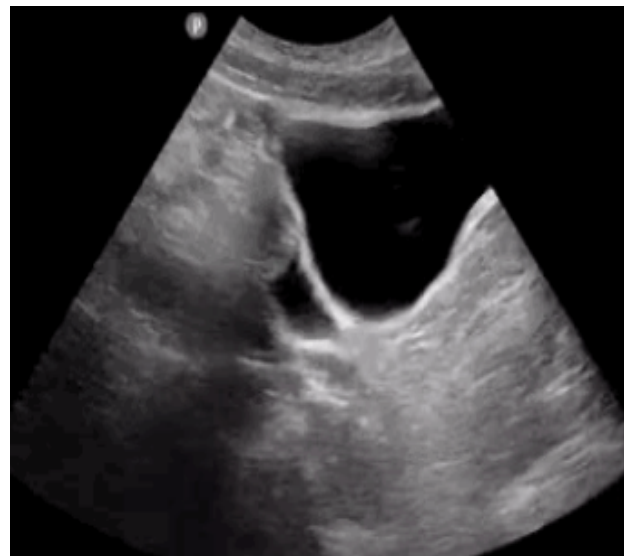


4.10b Pericardial effusion with tamponade effect (RV collapsed in diastole).

Suprapubic View



4.11a Normal Suprapubic long axis view.



4.11b Free fluid seen in rectovesical region.

Which area to scan first?

For trauma patient with dyspnea and hypoxia :

1. Start with lung ultrasound of both lungs to look for pneumothorax.
2. Later proceed with pericardial view to look for cardiac tamponade.
3. Finishes with RUQ, LUQ and suprapubic view.

For trauma patient with hypotension:

1. Start with pericardial view to look for cardiac tamponade.
2. Later proceed with RUQ , LUQ and suprapubic view to look for free fluid.
3. Finishes with lung ultrasound.

For stable trauma patient with blunt trauma:

1. Performed eFAST after physical examination in primary survey.
2. Start with :
 - (a) Lung ultrasound (Airway and Breathing)
 - (b) Pericardial view (Circulation)
 - (c) RUQ view (Circulation)
 - (d) LUQ view (Circulation)
 - (e) Suprapubic view (Circulation)

Inferior Vena Cava & Aorta

IVC and Aorta

Objectives

1. Able to describe the indications for performing bedside ultrasound for abdominal aorta and IVC.
2. Able to describe and correlate anatomic structures of great vessels with findings on ultrasound.
3. Able to evaluate for abdominal aortic aneurysm and dissection.

Technical requirement

A. Probe :

- Curvilinear (best to see IVC and Aorta).
- Phased array / Cardiac probe.

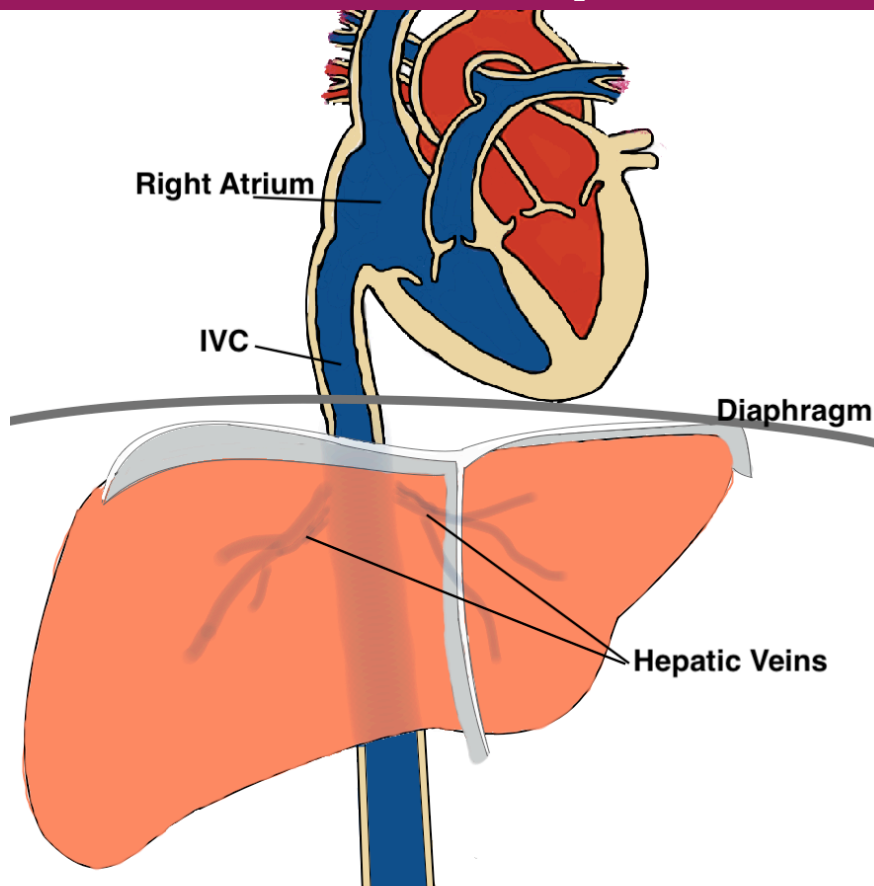
B. Mode :

- B mode.

C. Patient position :

- Supine.

Normal Anatomy IVC



5.1 Anatomy of inferior vena cava and its related structures that can be visualized in ultrasound.

Ultrasound Technique for IVC

Landmarks for IVC Ultrasound

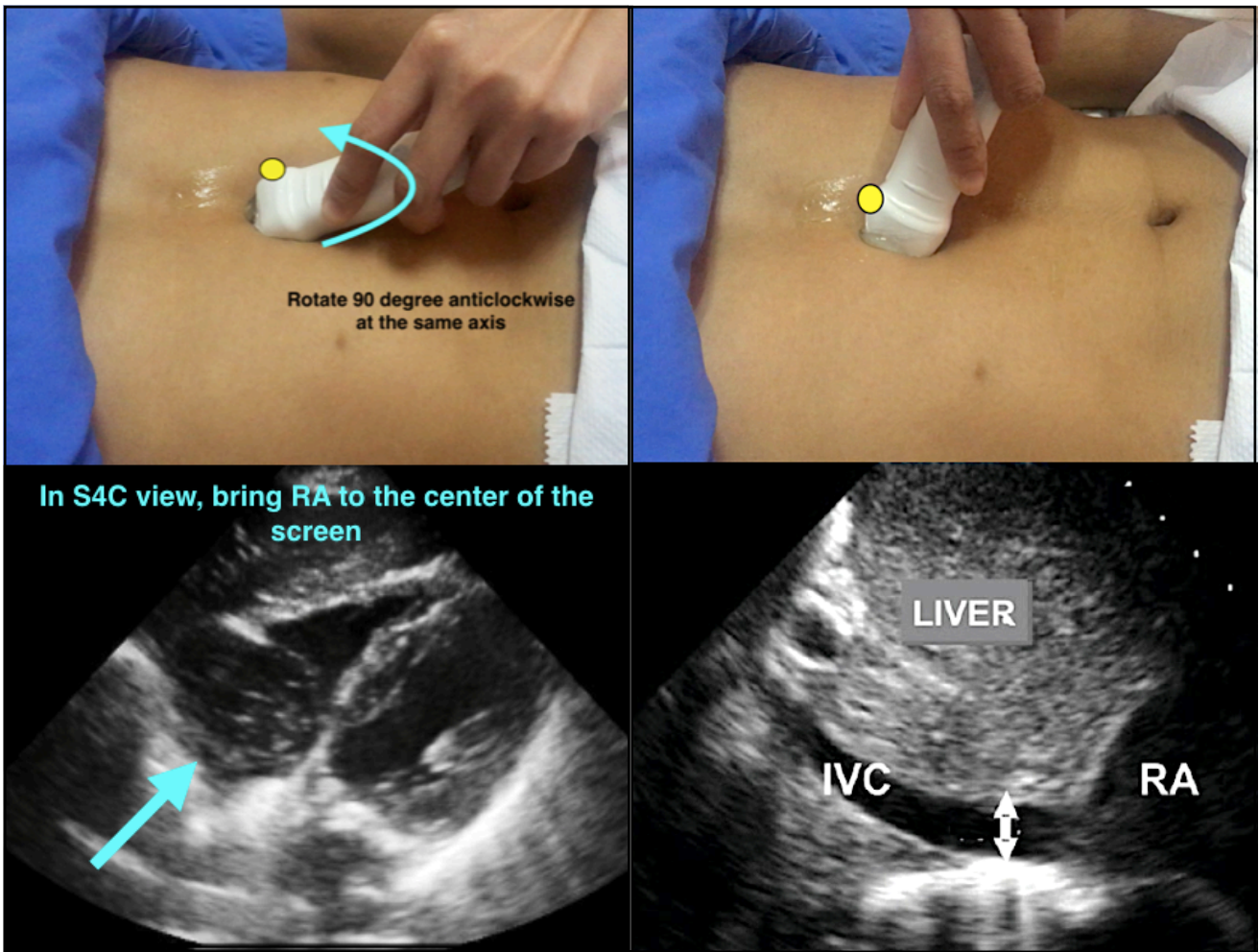
1. Right Atrium
2. Inferior vena cava
3. Hepatic Veins

Techniques:

There are 2 methods to look for Inferior Vena Cava.

1. **Identify IVC by locating RA in subxiphoid four chamber view (usually by using cardiac probe).**
 - a. From subxiphoid 4 chamber view, at the level of right atrium rotate the probe anti-clockwise 90 degree.
 - b. Place the probe in longitudinal orientation to the subxiphoid region.
 - c. Tilt the probe toward patient's right and slightly rock the probe towards cranial and under the rib margin.
 - d. The inferior vena cava can be seen entering the right atrium.
 - e. The IVC also can be differentiated from the aorta by seeing the diameter variability on respiration.
2. **Xiphoid process as palpable landmark.**
 - a. Place the curvilinear probe longitudinally just below the xiphoid process.
 - b. Probe indicator pointed towards cranially with atrium as a landmark.
 - c. Tilt the probe slightly to the right to view the IVC and identify its draining into right atrium.

Method 1



5.2a To identify the IVC, rotate the probe anticlockwise 90° once you visualize the RA in S4C.

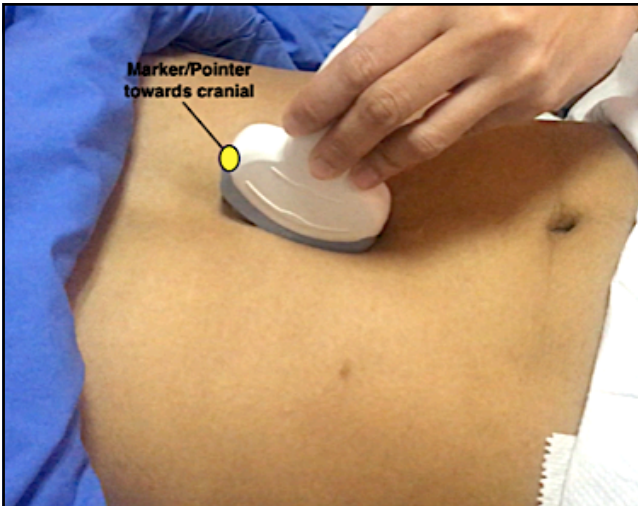
5.2b The only landmarks to verify that you are indeed imaging the IVC is that the tubular structure is connected to the right atrium.

Video on method 1

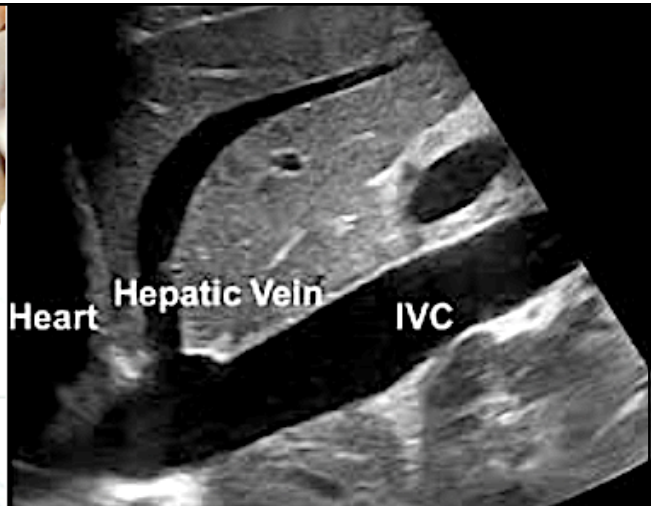


5.3 Video on method to view the IVC starting from S4C.

Method 2



5.4a Other method to view the IVC is by placing the probe at the subxiphoid with marker towards cranial. Rock the probe slightly upward until you see the RA.



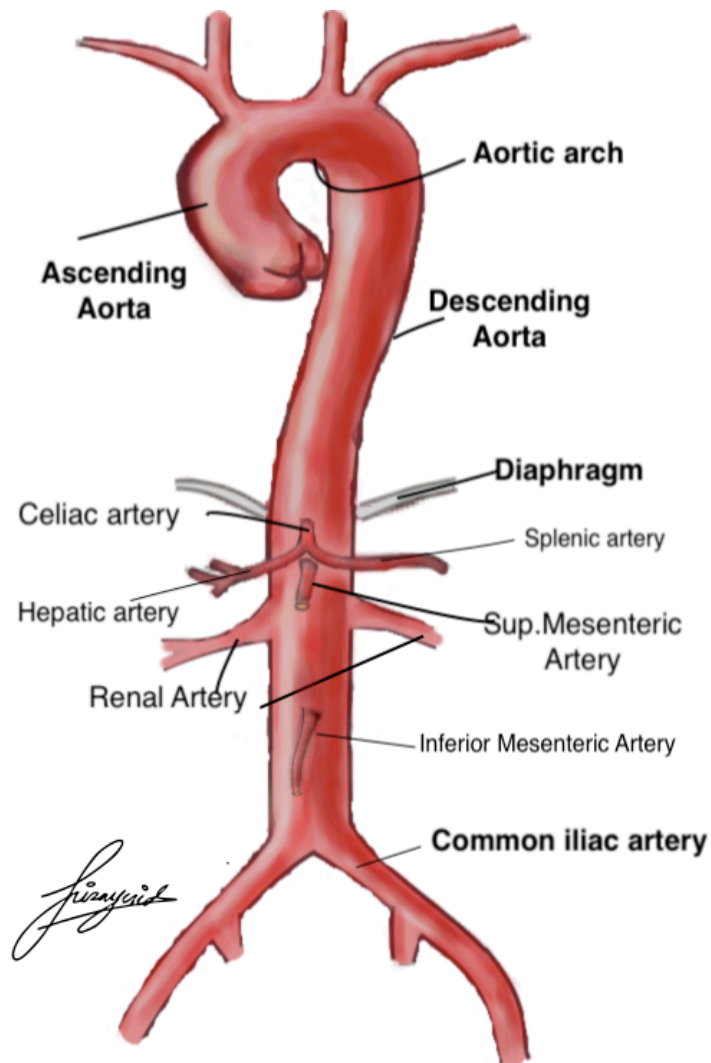
5.4b Hepatic vein(s) is seen connected to IVC and drained into RA.

Video on method 2



5.5 Video on method to view the IVC by rocking and tilting the probe.

Normal Anatomy Aorta



5.6 Anatomy of Thoracoabdominal Aorta and its major branches.

Ultrasound Technique for Aorta

Landmarks for Aorta Ultrasound

1. Inferior vena cava
2. Vertebrae body
3. SMA and Celiac trunk
4. Renal arteries
5. Common iliac arteries

Techniques:

There are 2 views for Abdominal Aorta ultrasound.

1. Long Axis view
2. Short Axis view

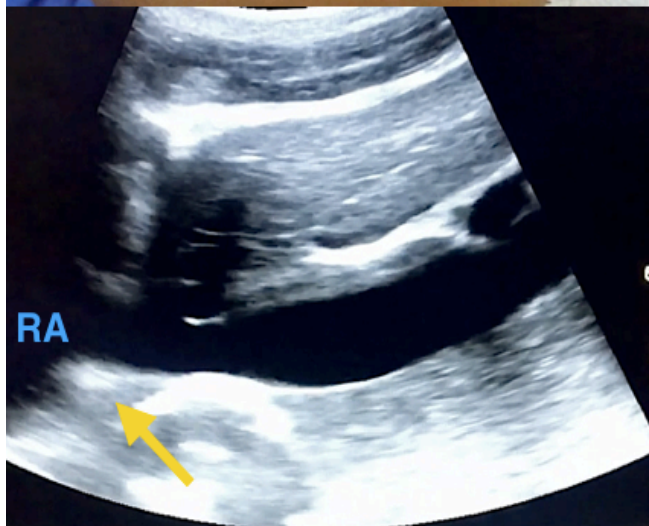
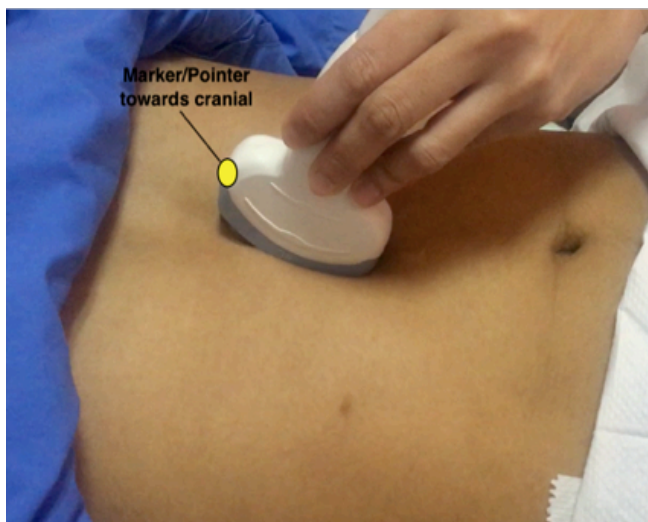
Long Axis view.

You can either start with long axis view or short axis view first.

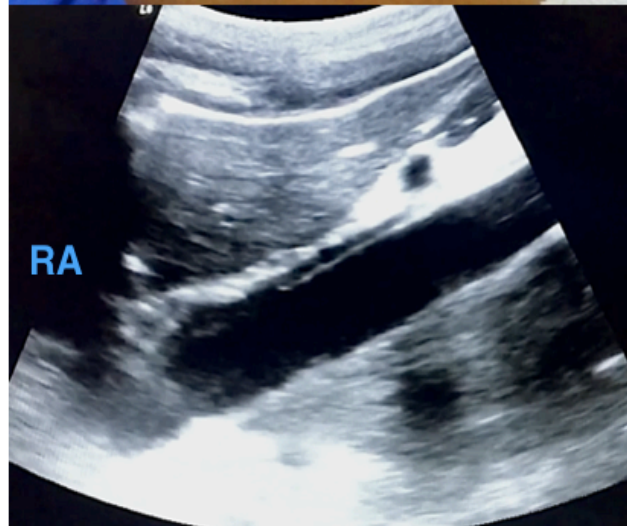
However it is best to start with long axis view by visualizing the whole abdominal aorta until it bifurcates to common iliac arteries to detect aneurysm.

Step 1. Orient the probe.

- Place the probe vertically (with its indicator towards patient's head) just below the xiphoid process.
- After identify the IVC/RA, tilt the probe slightly to patients' left until you see the aorta.



5.7a Using curvilinear probe, identify the RA. If the vessel connected to RA, it is an IVC.



5.7b To view the Aorta, tilt the probe slightly to patient's left. A tubular structure that not connected to RA is an Aorta. Aorta doesn't vary with respirations.

Step 2. Identify Celiac trunk and Superior Mesenteric artery (SMA).

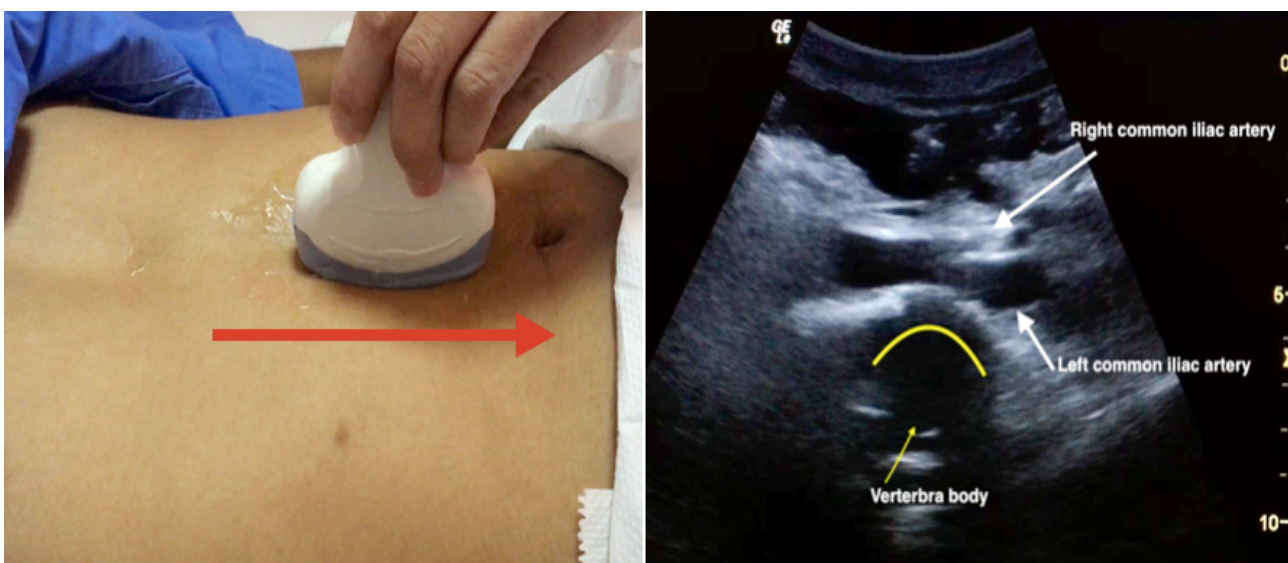
- Once you identify the aorta, slide the probe downward until you see the two vessels emerging from the aorta.
- Celiac trunk will be superior to SMA.



5.8 The SMA arises from the anterior portion of the aorta just distal to the celiac artery.

Step 3. Slide the probe downward longitudinally until umbilical level.

- Visualize the Aorta until it bifurcates into common iliac artery (at the level of umbilicus).
- Look for normal anatomy or aorta, measure any bulging (fusiform or saccular aneurysm) in short axis view.



5.9 Slide the probe downward vertically until reaching the umbilicus. The bifurcation of abdominal aorta into right and left iliac arteries is usually seen at the level of L4/Umbilical.

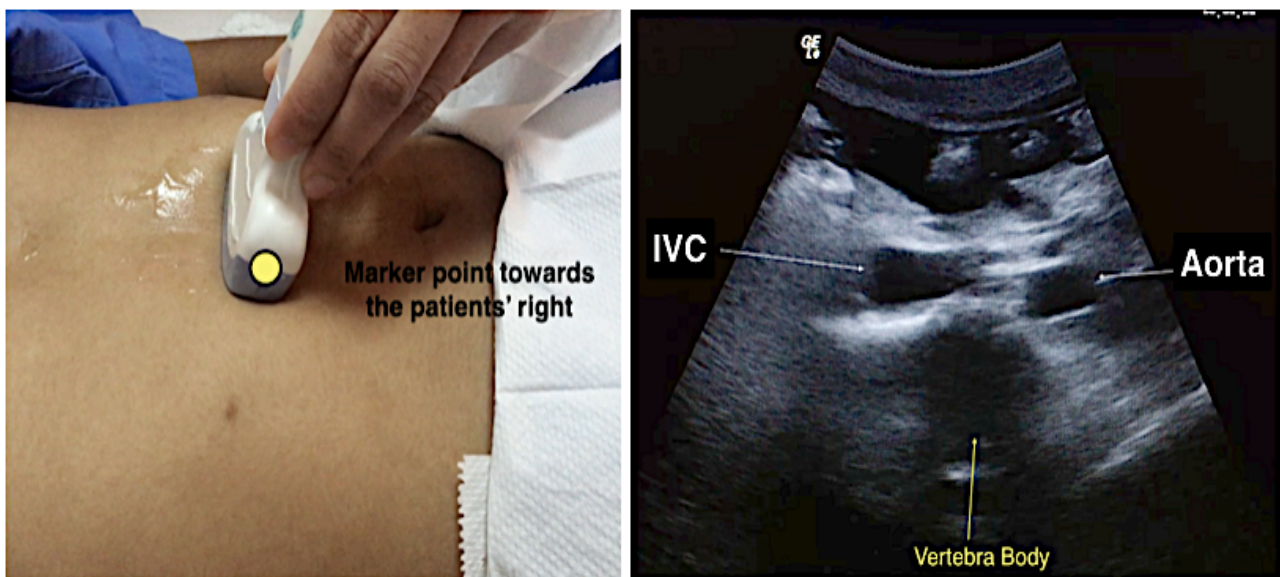
Short Axis view.

Switch from long axis to short axis (transverse view). It comprises of four levels:

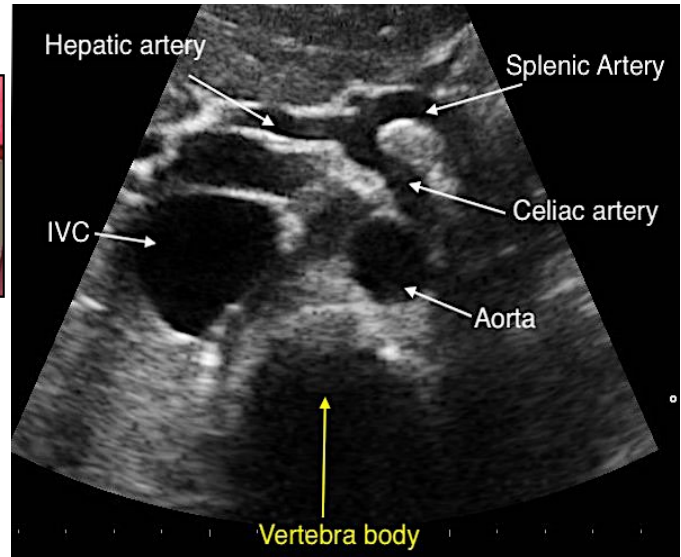
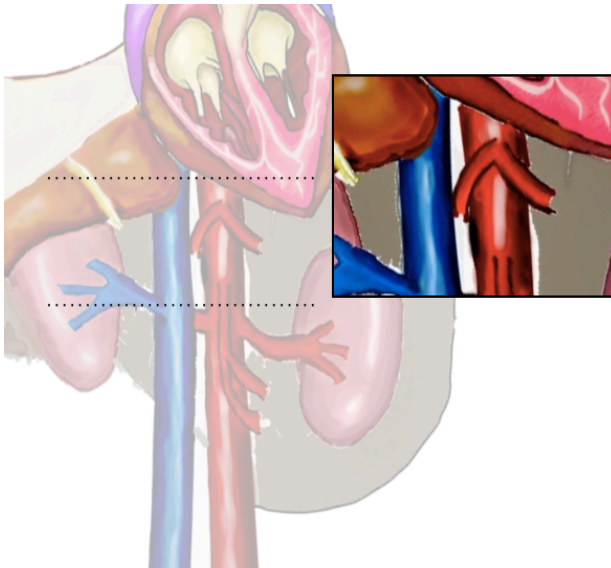
- a. Proximal aorta
- b. Mid Aorta
- c. Distal Aorta
- d. Aortic bifurcation

Step 1. Proximal Abdominal Aorta.

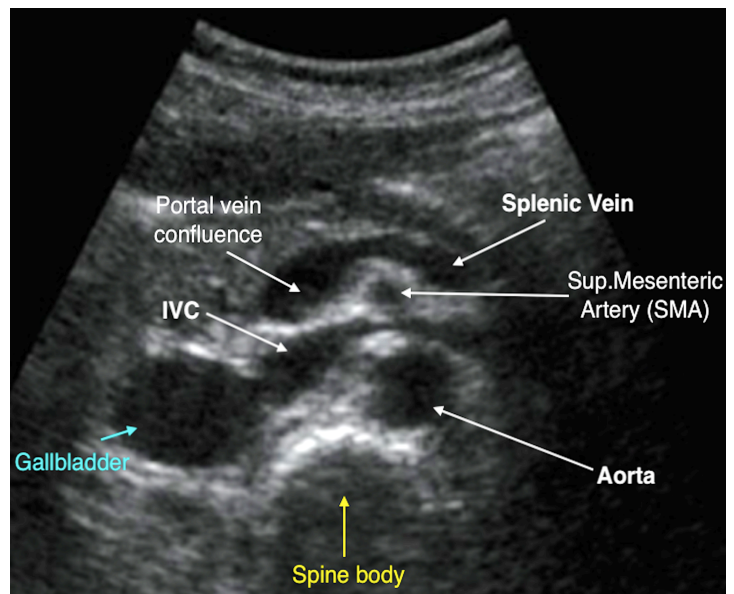
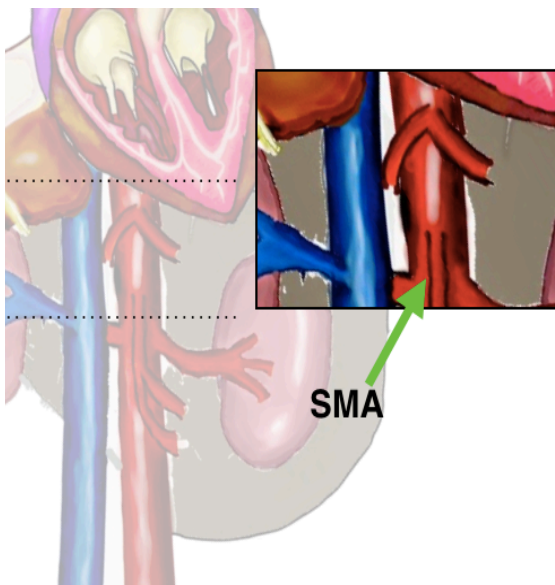
- a. Place the probe horizontally just below the xiphoid process with slightly left to patient's midline.
- b. Alternatively , rotate anticlockwise 90° from long axis view of abdominal aorta at epigastric level. With marker points toward patient's right.
- c. Identify the Aorta (thick walled, pulsatile circle) and IVC (oval shape/flattened, usually collapsible with respirations).
- d. Visualize the Celiac trunk by slightly sliding the probe inferiorly.
- e. Visualize the Superior Mesenteric Artery by slowly sliding inferiorly a bit further. It shouldn't be far since the SMA originates just distal to celiac trunk.
- f. When you see the SMA, you are reaching the mid abdominal aorta.



5.10 While scanning and sliding the probe distally, pay attention to the landmarks (e.g vertebra body and IVC) and not getting off course.



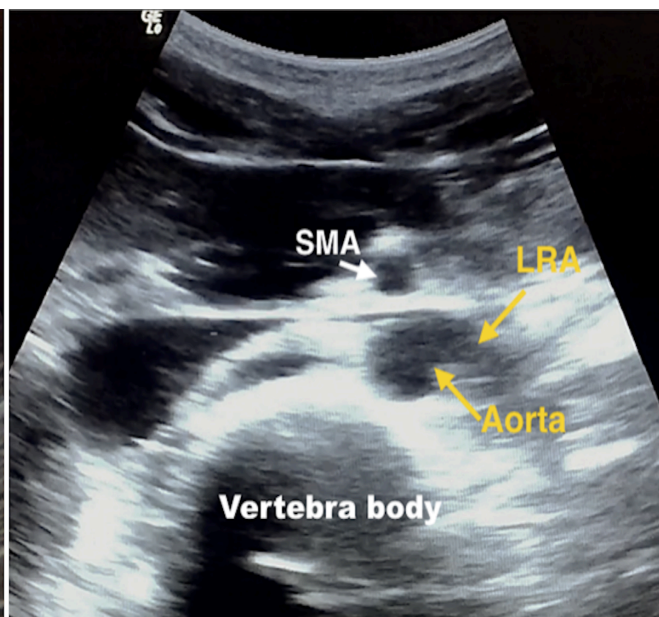
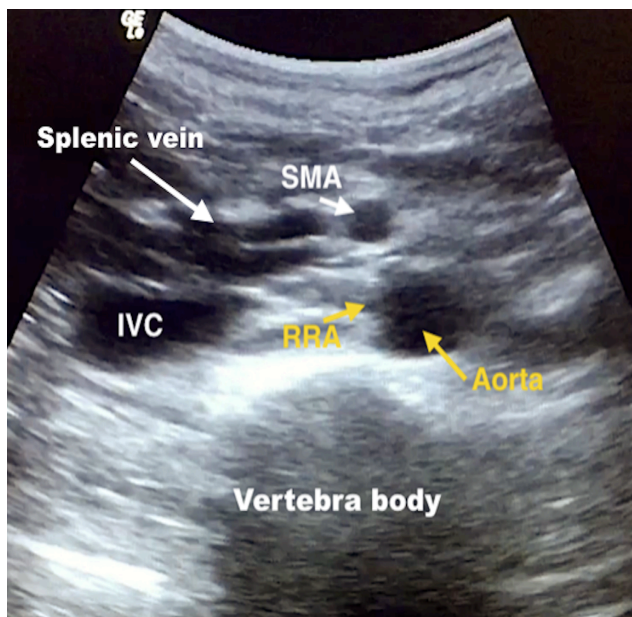
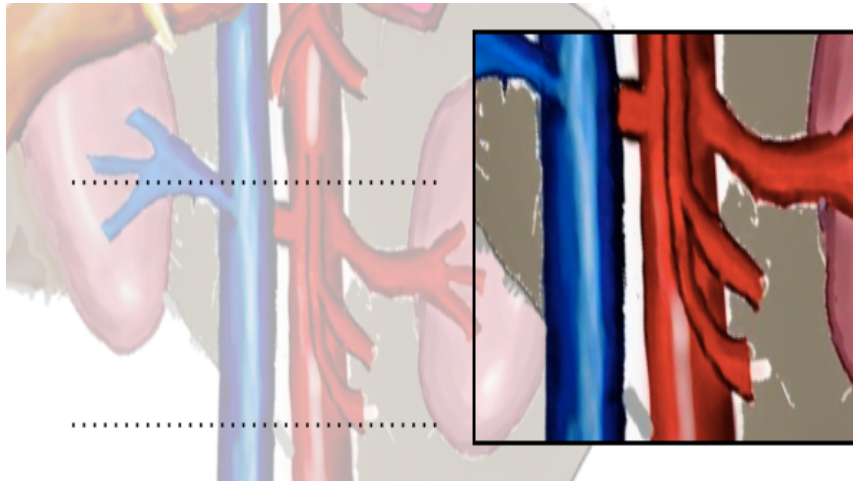
5.11 The Celiac trunk is the first major branch of abdominal aorta. Look for the 'seagull' sign, which the wings are hepatic artery and splenic artery.



5.12 The SMA is the second major branch of abdominal aorta. The splenic vein passes anterior to SMA.

Step 2. Mid Abdominal Aorta.

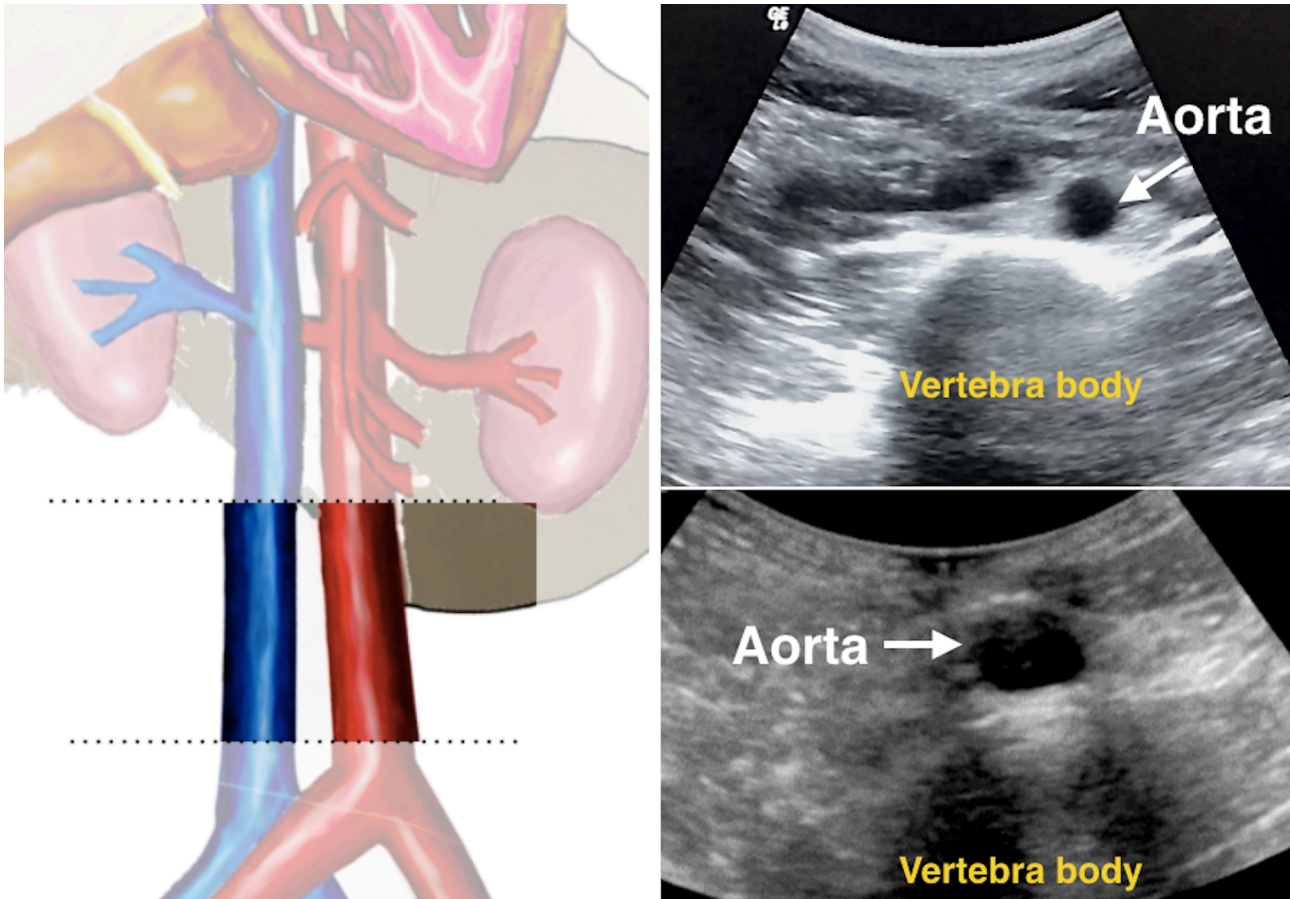
- From SMA view, slide the probe more distally, keeping the aorta in view (center of the screen) at all times.
- Occasionally you will be able to visualize the renal arteries.



5.13 Continue sliding the probe distally in transverse plane, keeping the aorta in view entire time. Ideally (sometimes difficult to get), you can visualize the renal arteries in which the RRA will appear before LRA.

Step 3. Distal Abdominal Aorta.

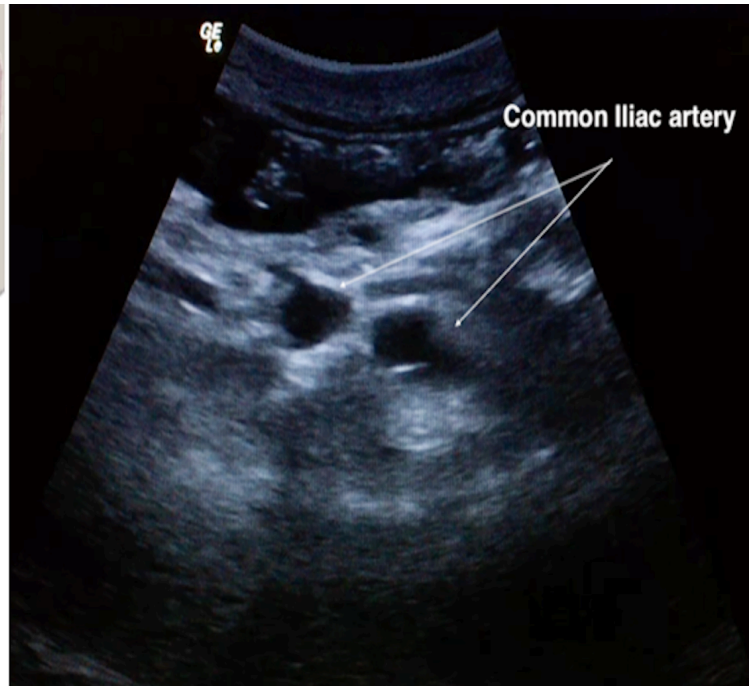
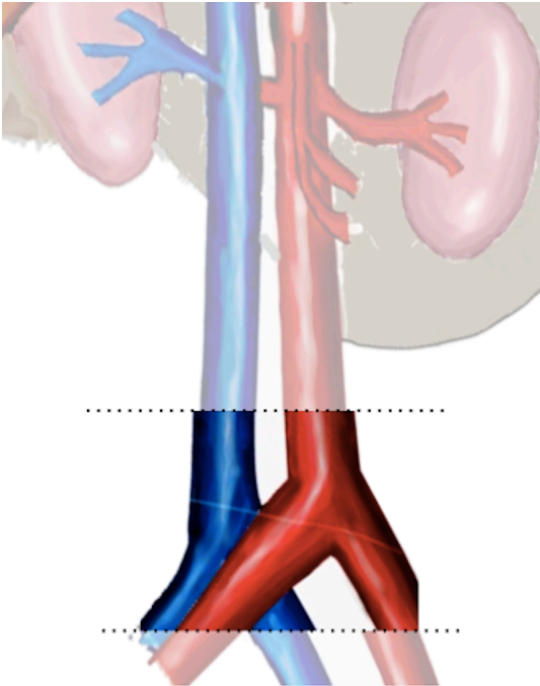
- From mid aorta, as you scan inferior to the renal arteries, you will see the distal abdominal aorta.
- Distal aorta is where the aorta is most superficial, and you may need to reduce the depth.



5.14 Image obtained by sliding the probe more distally. Note the lack of clearly identifying landmarks is typical for distal aorta (some author label it as lower portion of midaorta).

Step 4. Aortic Bifurcation.

- Slide down slowly until umbilicus, this is where the aorta bifurcates into right and left common iliac arteries.
- Due to anatomy variant, you can see the bifurcation either just above the umbilicus or more inferior past the umbilical level.

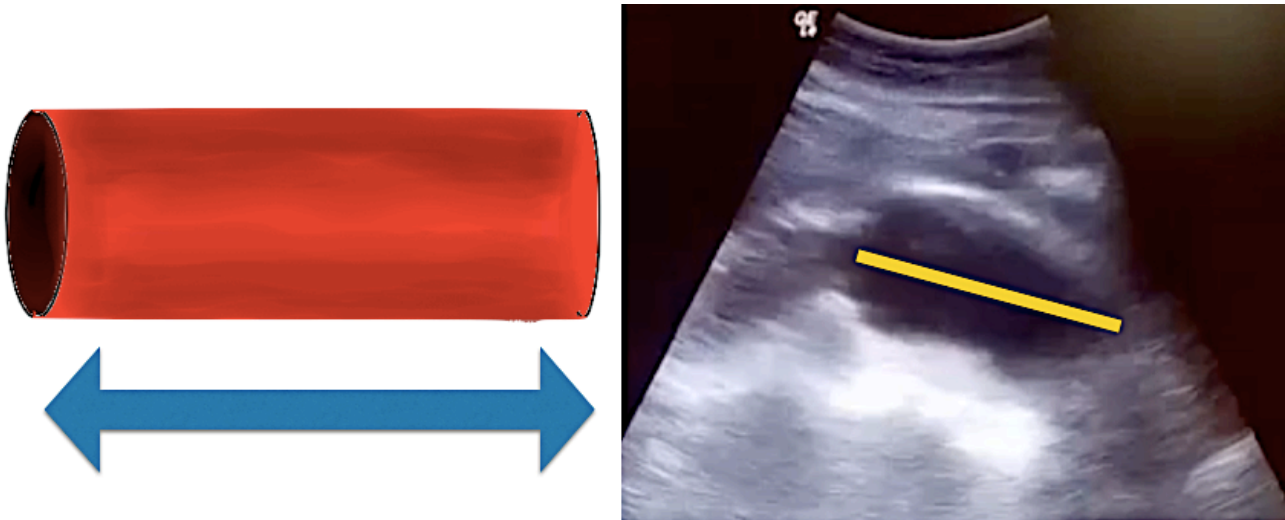


5.15 Image obtained while sliding the probe distally at the level of distal aorta, through the bifurcation into common iliac arteries.

How to measure Aorta

Long Axis view.

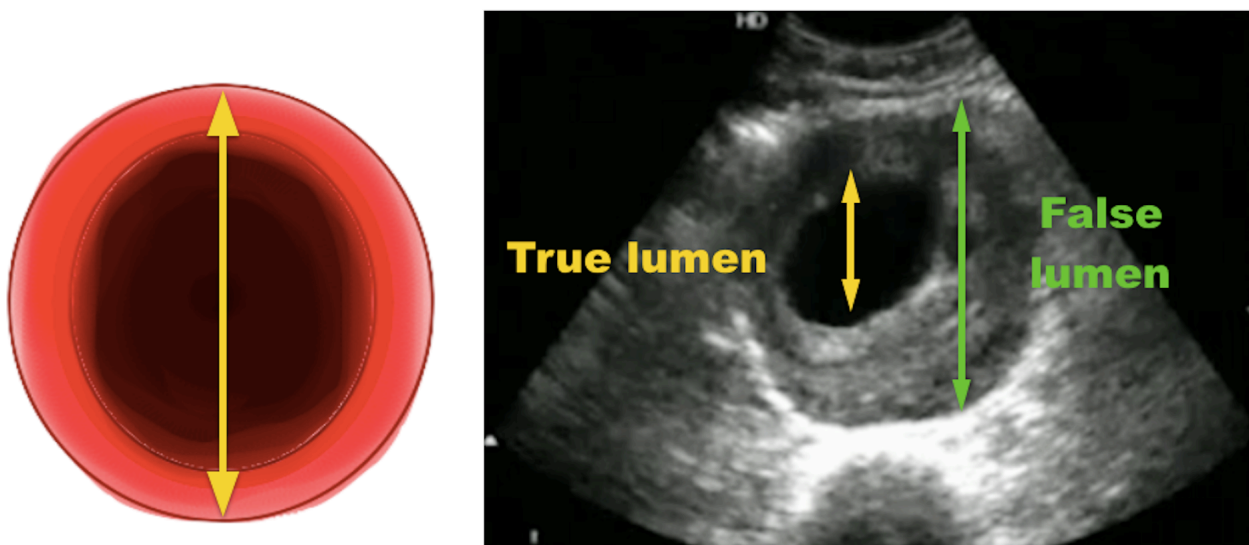
- To measure the length of aorta or length of the aneurysm



5.16 The long axis is an ideal view to measure the length of aortic aneurysm. Measurement of aorta diameter in long axis sometimes can be underestimate/inaccurate due to *cylinder tangent effect*.

Short Axis view.

- To measure the diameter of aorta or aneurysm size.
- Measurement must be done in short axis view by taking into account of maximum diameter (outer wall to outer wall).
- Normal Aorta diameter is < 3 cm.
- Normal common iliac arteries < 1.5 cm.



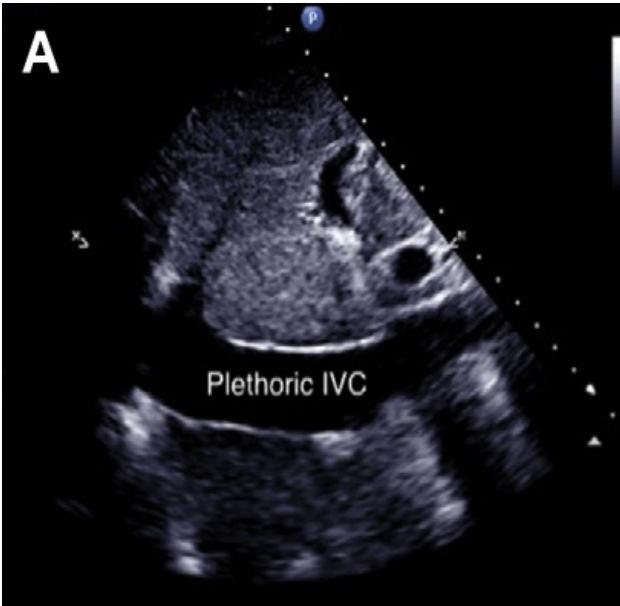
5.17 To get correct measurement of the aorta, you need to measure from outer wall to outer wall. AAAs often contain a mural thrombus that **must** be included in your measurement.


IVC Pathologies

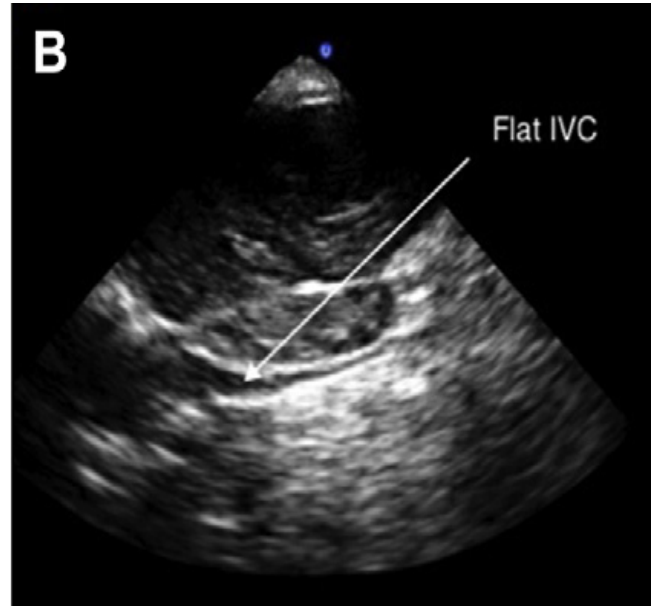
For beginners these 2 pathologic IVCs that you need to know:


A: Plethoric IVC - volume overload / Obstructive shock.

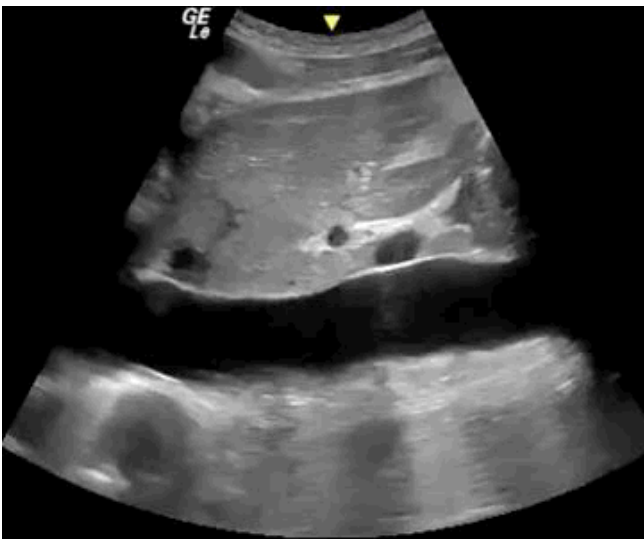
B: Flat IVC - Volume depleted.




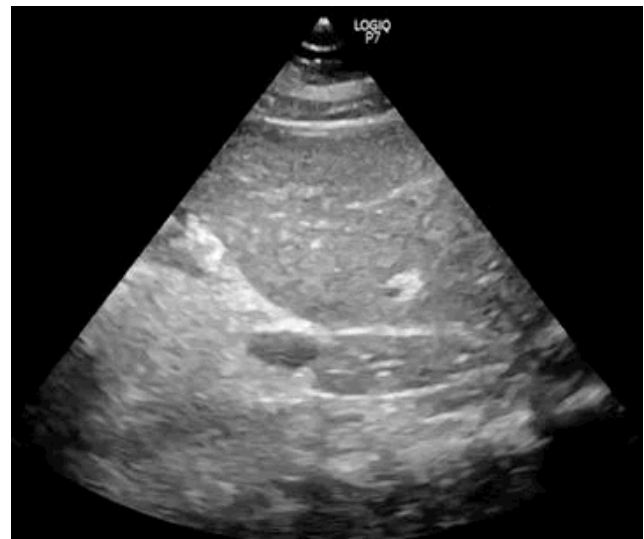
 **5.18a** Plethoric IVC (> 2 cm diameter) with minimal collapse with respiration indicates high volume or high pressure in the right heart.




 **5.18b** Collapsed IVC due to hypovolemia or low pressure in the right heart.



 **5.19a (video)** Plethoric IVC, showing poor collapsibility with respirations.



 **5.19b (vid)** Collapsed/flat IVC. Sometimes, the IVC is too flat, one unable to visualize the IVC. And might mistaken the aorta as IVC. Thus its very important to differentiate between IVC and Aorta.

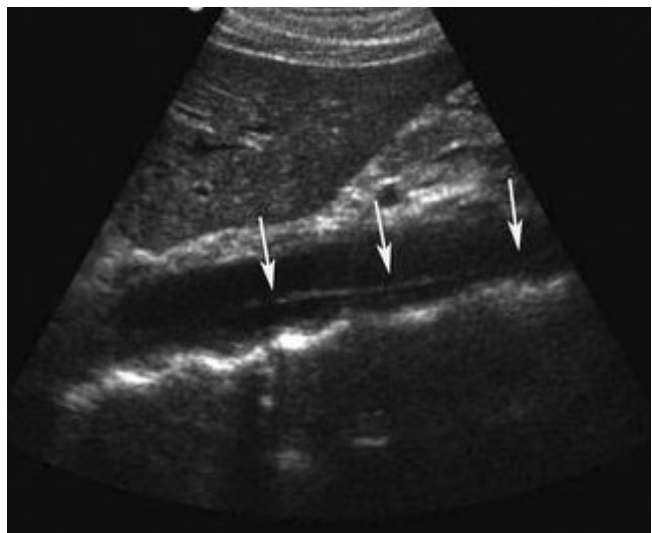
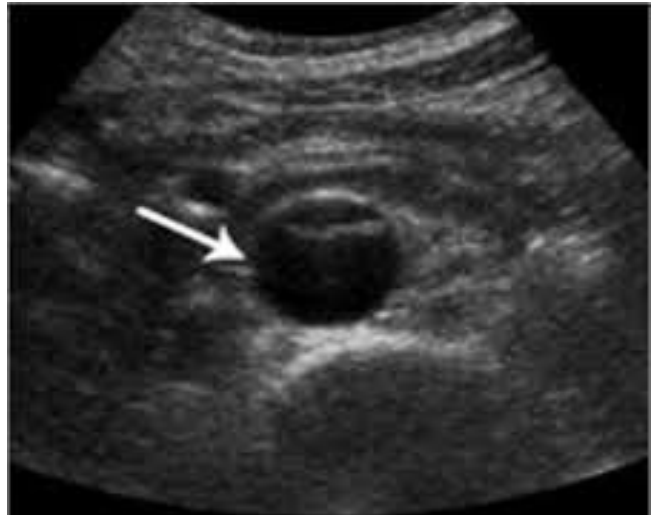
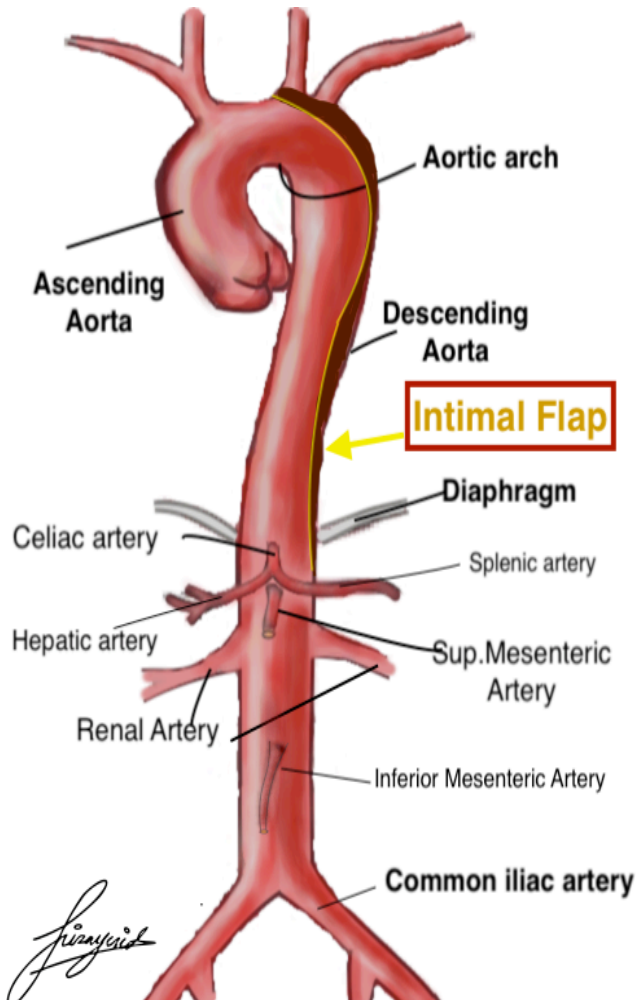
Aorta Pathologies

For beginners these 2 pathologic Aortas that you need to know:

A: Dissecting Aorta - Can occur with or without aneurysm.

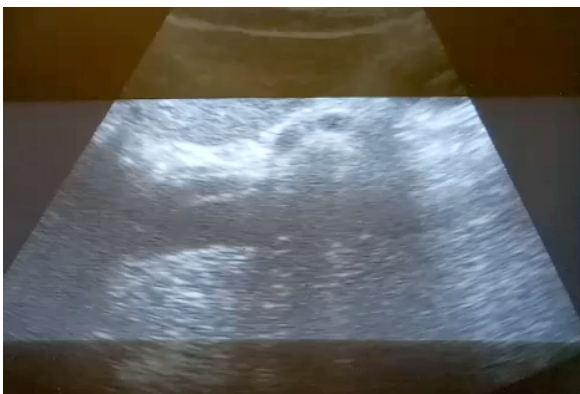
B: Aortic Aneurysm.

A : Aortic Dissection



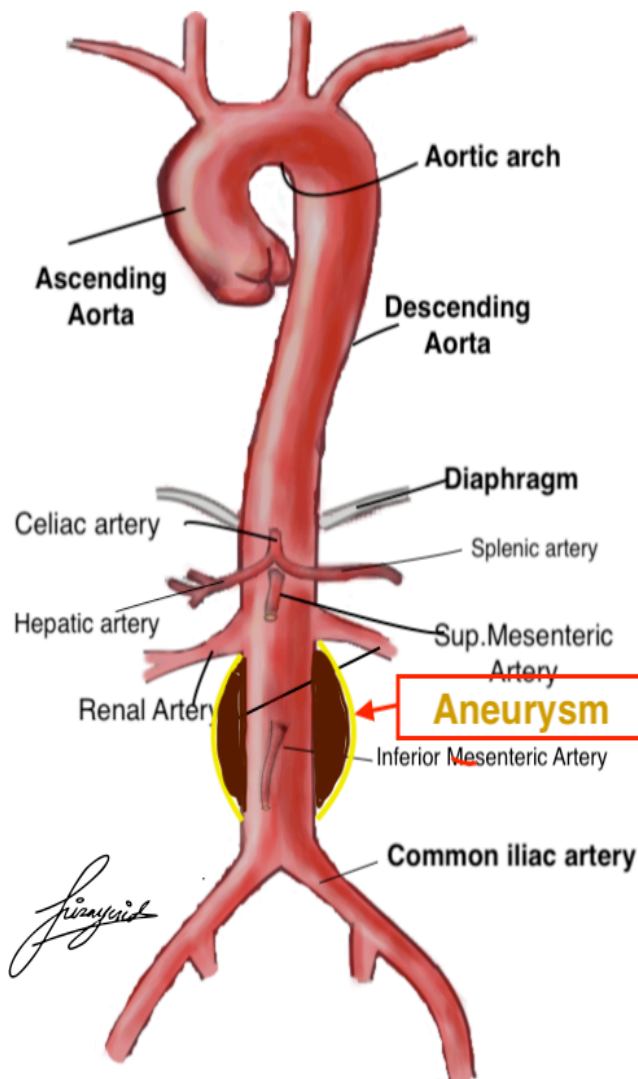
5.20 An aortic dissection is when the layers of the aortic wall pulls apart and the blood gets trapped in between. This weakens the aorta and risk of rupture.

5.21 Transverse and longitudinal ultrasound view showing the intimal flap (arrow).

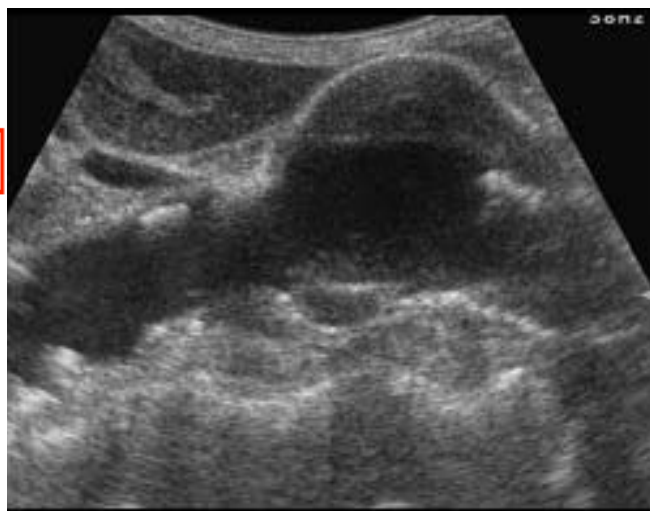


5.22 (vid) Pulsatile aortic dissection with saccular aortic aneurysm.

B : Abdominal aortic aneurysm (AAA) - is a focal dilatations of the abdominal aorta more than 3 cm.



5.23 Abdominal Aortic aneurysm is a bulge or dilatation of the abdominal aorta. It can be saccular type or fusiform type.



5.24 Transverse and longitudinal ultrasound view of abdominal aorta showing intramural thrombosis (false lumen) and saccular type of AAA.



5.25 (video) Ruptured AAA. Notice that the IVC is flat due to hypovolemia (haemorrhage), and hypoechoic area (free fluid) just above the aneurysm. These are the features of a ruptured AAA. Mortality associated with ruptured AAA is very high (> 90%).

Ultrasound in Shock

Ultrasound in Shock

To understand the basis of doing ultrasound in shock, one must appreciate the pathophysiology behind every type of shock.

A person's blood pressure (BP) is determined by cardiac output (CO) and total peripheral resistance (TPR). The CO is affected by two factors, the heart rate (HR) and the stroke volume (SV). The SV is the amount of blood pumped out of the left ventricle after one contraction. And is determined by preload, contractility of the heart and afterload. By understanding this formula, you can understand how baroreceptors response.

$$\text{MAP} = \text{CO} (\text{SV} \times \text{HR}) \times \text{TPR}$$

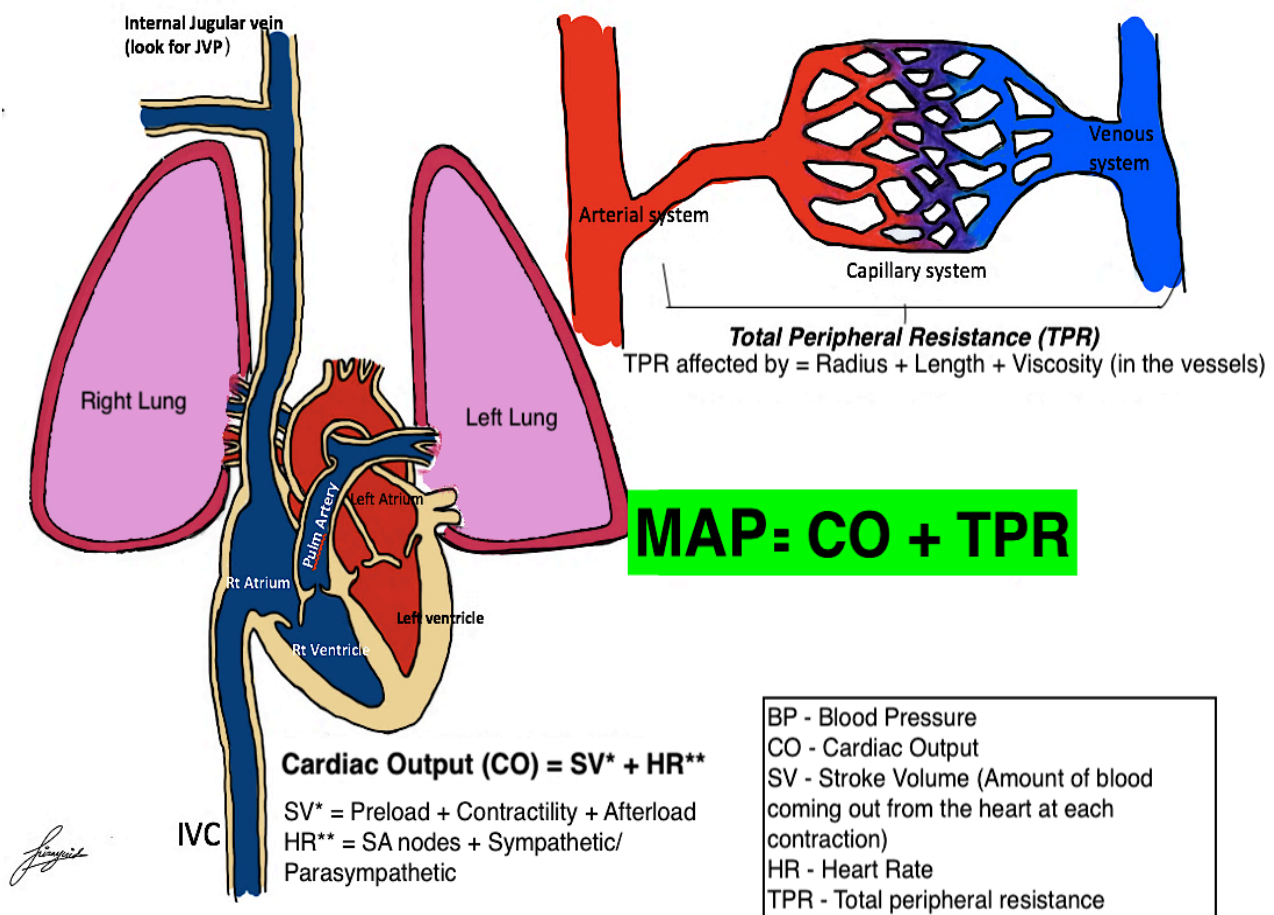
MAP = Mean arterial pressure.

SV = determined by **preload**, **contractility** and **afterload**.

HR = controlled by SA nodes influenced by **sympathetic** and **parasympathetic**.

TPR = Total peripheral resistance affected by **radius** and **length** of the vessels, along with intravascular **viscosity**.

When one factor is low or abnormal, the other factor will compensate to maintain the mean arterial pressure (MAP) by baroreceptors response. For example in hypovolemic shock, the venous return (aka preload) is low thus low SV. The body will response by increasing HR and TPR.



6.1 This diagram depicts of cardiovascular physiology. When the blood is pumped out of the left ventricle into the Aorta and distributing arteries, pressure is generated called MAP (which we measure during blood pressure taking). MAP is determined by the CO and TPR. Any changes in either CO or TPR will affect the MAP. While CO is determine by SV and HR, any changes in either one or both will affect the CO.

Cardiac output (CO) is the amount of blood pumped out by heart to systemic circulation in a minute. The cardiac output is the product of heart rate (HR) and stroke volume. Cardiac output can be altered with body demand e.g exercise or fever by modulating both HR and SV.

Stroke volume (SV) is the amount of blood ejected by left ventricle in one contraction (during systole). SV is one of *major determinate of cardiac output* and it also affected by several factors. And it depends on preload, contractility and afterload.

Preload is proportional to EDV (amount of blood in the ventricles immediately before systole). Low preload most commonly caused by reduced venous return whether due to haemorrhage or fluid loss, leads to low SV hence reduce CO.

Contractility describes the force of myocyte contraction, also referred to as inotropy. When the force of contraction increases, the heart is able to pump more blood out for the heart thus increases the SV. Myocardial infarction, myocardial depression due to toxin or sepsis may cause poor contractility hence leads to low SV.

Heart rate is determined by signals from SA nodes (the pacemaker of the heart). The autonomic nervous system (ANS) and hormones can affect the speed at which the SA node generates electrical impulse. This affects the HR (or chronotropy) which in turn affects the cardiac output. ANS has both sympathetic and parasympathetic divisions that work together to maintain balance. The parasympathetic input on SAN dominates at rest, to give normal resting HR. Any initial increases in HR are brought by reduction in parasympathetic outflow, and increasing the HR over 100bpm is via an increase sympathetic outflow.

Total peripheral resistance (TPR) refers to the resistance to blood flow offered by all of the systemic vasculature excluding the pulmonary vasculature. Vasoconstriction increases TPR and vasodilatation decreases TPR. Although TPR is primarily determined by changes in blood vessels diameter, changes in blood viscosity also affect TPR. High blood viscosity e.g in Polycythemia causes increases in TPR and indirectly causes increases MAP.

Type of shock

1. **Cardiogenic**
2. **Obstructive**
3. **Hypovolemic**
4. **Distributive**

1. **Cardiogenic Shock**

Causes : a). Myocardial infarction (STEMI/NSTEMI)
 b). Cardiomyopathy
 c). Myocarditis/Pancarditis

Clinical features :

Symptoms	Signs
Chest pain/epigastric pain.	Abnormal ECG.
Dyspnea.	Raised JVP.
Syncope.	Bilateral lungs fine crepitations.
Sudden lethargy.	CCTVR :
Sudden vomiting and profuse sweating.	Colour – Dusky/Pale.
	CRT - ≥ 2 secs.
	Temperature – cold & clammy.
	Volume – Low volume.
	Rate – Tachycardia or bradycardia.

***CCTVR** – indirect features of TPR. (i.e High TPR due to vasoconstriction, thus cool clammy peripheries)

Ultrasound findings for Cardiogenic Shock

Heart

- Poor contractility
- Presence of Regional Wall Motion Abnormality (RMWA)
- Dilated heart chamber/s
- Global hypokinesia +/-

Lungs

- Bilateral B lines (Base > Apical) +/-

IVC

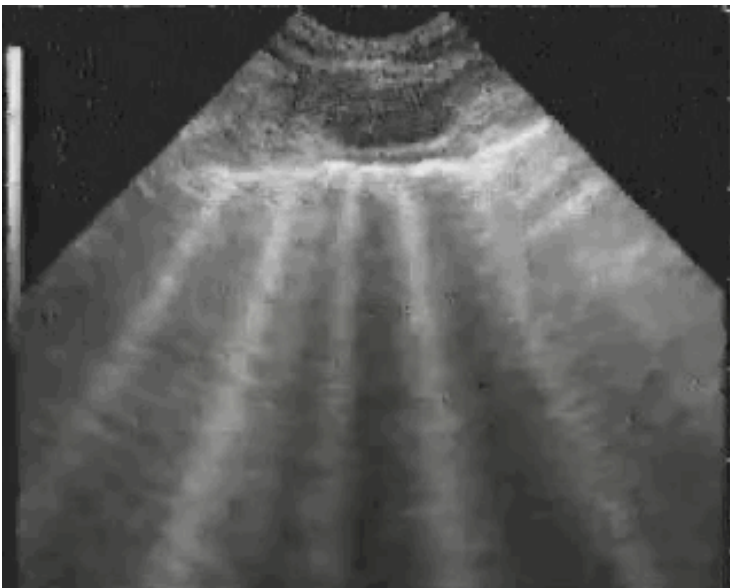
- Large or plethoric IVC (> 2 cm) with minimal collapsibility (low caval index)



6.2a PLAX view. Noted RMWA (hypokinesia) over anteroseptal wall (video).



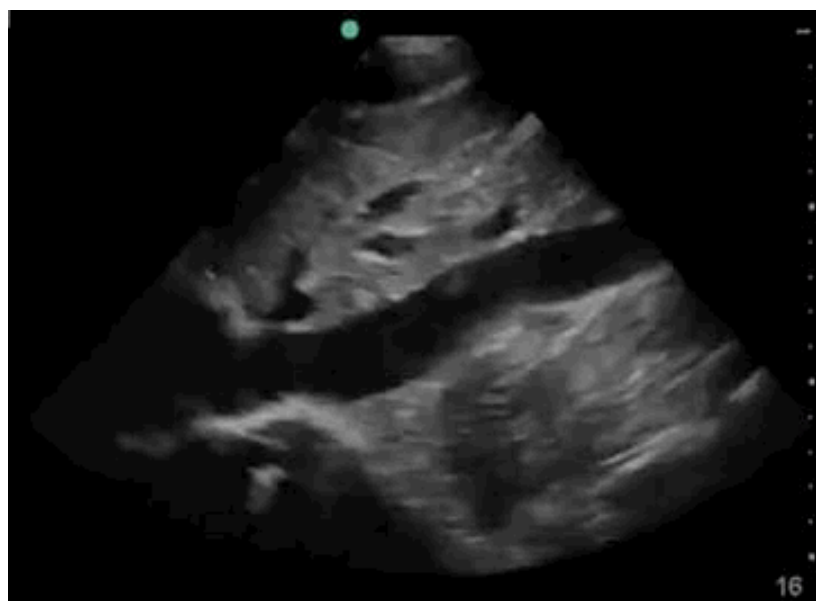
6.2b PSAX view. Noted RMWA (akinesia and dyskinesia) over anterolateral wall (video).



6.3 (video) Multiple B lines in lung ultrasound indicates presence of fluid in the alveolar interstitial space e.g. in Pulmonary oedema.



6.4 (video) Plethoric or large IVC is due to high pressure in the right heart (causing IVC congestion).



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2. Obstructive Shock

Causes: (1). Tension pneumothorax (Unilateral or Bilateral)
 (2). Cardiac tamponade (Trauma or non trauma cause)
 (3). Acute cor pulmonale (PE, ARDS, AMI)

Clinical features:

Tension Pneumothorax	Acute Cor Pulmonale	Cardiac Tamponade
Symptoms a. Chest pain b. Dyspnea Signs a. Reduced air entry with hyper resonance b. Flail chest (trauma) c. Subcutaneous emphysema d. SPO2 <96% HR ↑↑ e. Raised JVP f. CCTVR : Colour – Dusky/pale CRT - ≥ 2 secs Temperature – Cold & clammy. Volume – Low volume Rate – Tachycardia	Symptoms a. Chest pain b. Dyspnea c. Syncope d. Fever +/- Signs a. Clear lungs b. SPO2 < 96% (+/-) c. ECG – RBBB, S1Q3T3, sinus tachy d. CXR can be normal (in PE) e. Raised JVP f. CCTVR : Colour – Dusky/pale CRT - ≥ 2 secs Temperature – Cold & clammy Volume – Normal/low volume Rate – Tachycardia	Symptoms a. Chest pain b. Dyspnea c. Syncope Signs a. Becks Triad (Hypotension, raised JVP, muffled heart sound) b. sPO2 > 96% c. ECG Electrical alternans +/- d. CXR can be normal or large globular heart shadow. e. CCTVR : Colour – Dusky/pale CRT - ≥ 2 secs Temperature – Cold & clammy Volume – Pulsus Paradoxus Rate – Tachycardia

Ultrasound findings for Obstructive Shock

Cardiac Tamponade

Heart

- Pericardial effusion, RV collapsed during diastole, small LV, Dancing heart (large effusion).

Lungs

- A lines, B lines +/- (can be normal lung or congested lung).

IVC

- Large and plethoric with very poor respiratory variability.



6.5 (vid) Massive pericardial effusion and dancing heart in pericardial tamponade.



6.6 (vid) Dry lungs in early cardiac tamponade. However in late cardiac tamponade, the lungs might be congested.



6.7 (vid) Plethoric IVC with poor variability due to flow obstruction into the right heart caused by heart compression (by pericardial effusion).

Tension pneumothorax

Heart

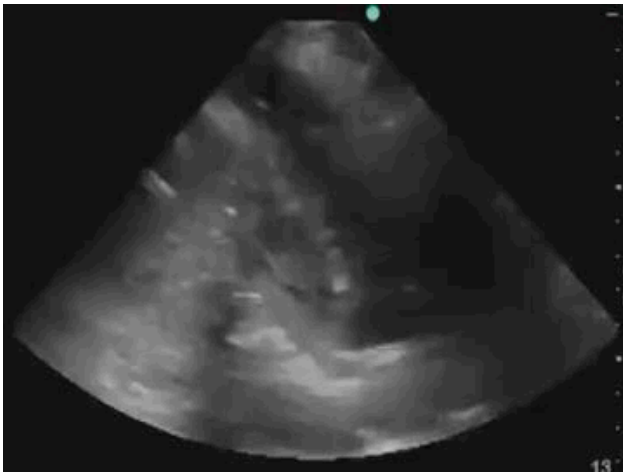
- Small heart, compressed LV/RV.
- Hyperdynamic heart (similar echo finding in hypovolemia, the only difference is in IVC).

Lungs

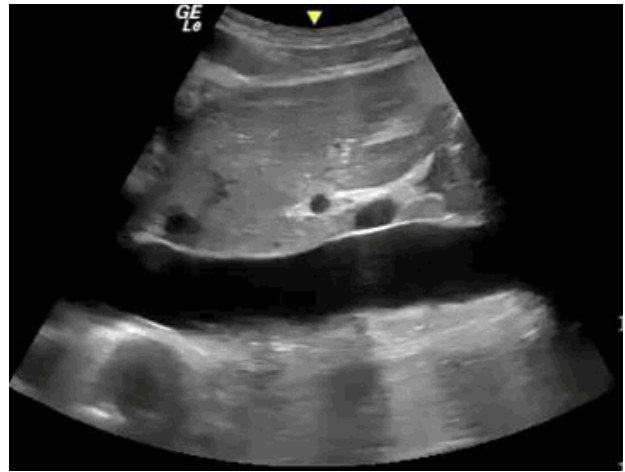
- A lines, absent sliding sign, lung point +/- , absent lung pulse.
- Barcode sign/stratosphere sign.

IVC

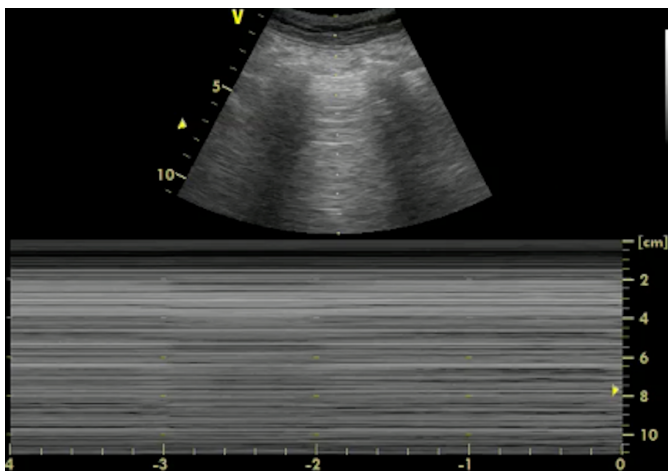
- Large and plethoric with very poor respiratory variability.
- * IVC will be plethoric in all types of obstructive shock.



6.8 (vid) Hyperdynamic heart with kissing ventricles due to external compression (tension pneumothorax).



6.9 (video) Plethoric IVC with poor variability due to high pressure in the thorax causing poor flow into the right heart.



6.10 Barcode/stratosphere sign during M mode (in pneumothorax).



6.11 (vid) Lung point in pneumothorax.

Cor Pulmonale

Heart

- Large RV with McConnell's sign, paradoxical movement of LV septum, D shaped RV.
- Intraventricular clot +/- , Trouser's sign (dilated PA).

Lungs

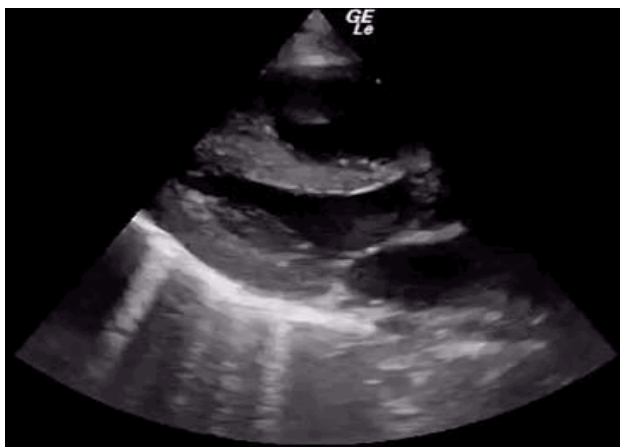
- A lines (normal dry lungs) - in pulmonary embolism.
- Diffused bilateral B lines - in Acute respiratory distress syndrome (ARDS).

IVC

Large and plethoric with very poor respiratory variability.

DVT - 2 point compression test for both legs if suspect PE)

- Presence of blood clot/DVT (If presence, it strongly suggestive of PE. However, you need to calculate PE risk score / Wells Score)



6.11a Grossly dilated RV with paradoxical movement of septal wall.



6.11b Thrombus in the RA, McConnell sign, paradoxical movement of the septal wall strongly supported the diagnosis of PE.



6.12 Dry lungs in PE causing acute cor pulmonale.



6.13 Plethoric IVC

3. Hypovolemic Shock

Causes : (1). Fluid loss (e.g Vomiting,Diarrhea,Polyuria,or reduce intake)
(2). Haemorrhage (Trauma or non trauma e.g ruptured AAA,UGIT bleed)

Clinical features:

Symptoms:

- a. Lethargy
- b. Altered mental status +/-
- c. Dyspnea +/- (due to pneumonia or metabolic acidosis)
- d. Near syncope / postural syncope
- e. Pain – chest/abdominal (for ruptured Aortic aneurysm or PGU/UGIT)

Clinical signs:

- a.Pale (esp if hemorrhagic)
- b.Dehydrated (coated tongue,dry mouth,sunken eyes)
- c. Abdomen tenderness or guarding
- d. Pulsatile and expansile abdominal mass (AAA)
- e. Radio-radial/Radio-femoral delay (Thoracic/ Abdominal AA)
- f. ECG – Sinus tachy, non specific ST changes
- g. JVP ↓↓
- h. **CCTVR :**
 - Colour – dusky/pale
 - CRT - ≥ 2 secs
 - Temperature – cold & clammy
 - Volume – low volume
 - Rate – tachycardia

Ultrasound findings for Hypovolemic Shock.

Heart

- Hyperdynamic heart.
- Small / kissing LV.

Lungs

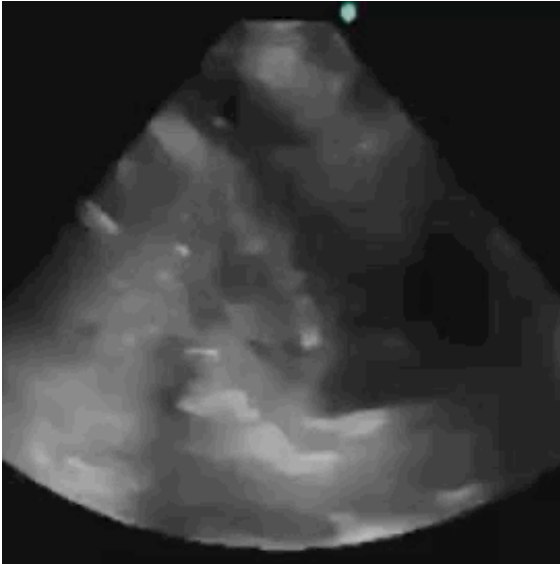
- Majority normal A lines – Clear lung.
- B lines (if pneumonia).
- Pleural effusion (if pneumonia/3rd space loss i.e hypoalbuminaemia,lung Ca).

IVC

- Kissing IVC or Small IVC <1.5 cm.
- Sometimes unable to visualize the IVC (severely collapse).

Abdomen

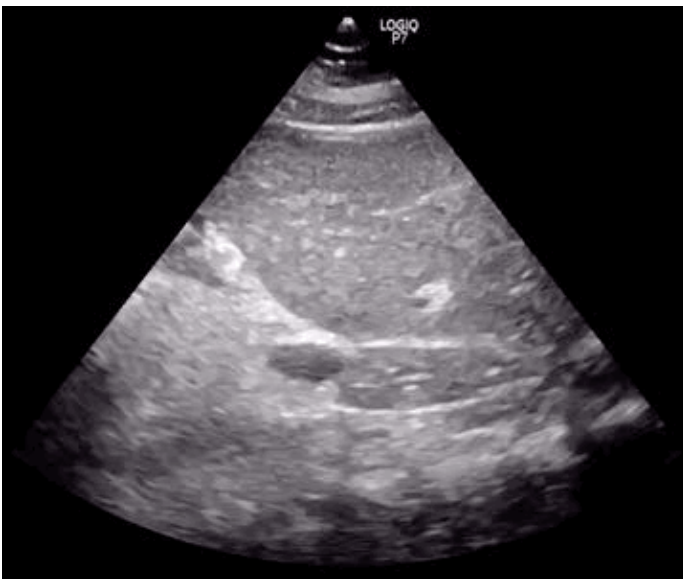
- Aorta – AAA.
- Free fluid – Perforated viscous/ruptured ectopic.



6.14 (video) Hyperdynamic heart with kissing ventricles due to severe hypovolemia.



6.15 (video) Ruptured Abdominal Aortic Aneurysm is one of the concealed cause of hemorrhagic shock.



6.16 (video) Kissing IVC due to severe hypovolemia/hemorrhage. Note that the IVC is severely collapsed that one's might be having difficulty to visualize, and sometimes mistaken the aorta as IVC.



6.17 (video) Free fluid in Morrison pouch indicates intraabdominal bleeding especially in trauma.

4. Distributive Shock

Causes: (1) Septic shock (any infection).

(2) Anaphylactic shock.

(3) Neurogenic shock* (trauma due to spine injury or non trauma-rare).

*Should be consider after ruled out hemorrhagic shock in trauma patient.

Clinical features:

<p>Anaphylactic Shock</p> <p>Symptoms</p> <ul style="list-style-type: none"> a. Angioedema b. Dyspnea c. Urticarial rash d. Abdominal pain/vomiting <p>Signs</p> <ul style="list-style-type: none"> a. Alert (mostly) b. JVP normal c. Wheezing/Stridor d. CCTVR : <p>Colour-Hypoaemic skin</p> <p>CRT - ≥ 2 secs</p> <p>Temperature – Warm</p> <p>Volume – Bounding</p> <p>Rate – Tachycardia</p>	<p>Neurogenic Shock</p> <p>Symptoms</p> <ul style="list-style-type: none"> a. Quadriparesis /quadriplegia / Paraparesis/paraplegia b. AUR c. Backpack/Neck pain +/- d. Dyspnea (respiratory paralysis) <p>Signs</p> <ul style="list-style-type: none"> a. Alert (if no head injury) b. JVP normal c. Priapism +/- d. CCTVR : <p>Colour – Normal skin</p> <p>CRT - ≥ 2 secs</p> <p>Temperature – Warm</p> <p>Volume-Normal/Bounding</p> <p>Rate – Normal/Bradycardia</p>	<p>Septic Shock</p> <p>Symptoms</p> <ul style="list-style-type: none"> a. Lethargy b. Altered mental status c. Dyspnea (due to infection/metabolic acidosis) d. Feverish <p>Signs</p> <ul style="list-style-type: none"> a. Septic looking b. JVP normal c. ECG – N@AbN d. CCTVR : <p>Colour – Mottled skin</p> <p>CRT - ≥ 2 secs</p> <p>Temperature – Warm</p> <p>Volume – Bounding</p> <p>Rate – Tachycardia</p>
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* **CCTVR** – indirect features of TPR. (i.e LOW TPR due to vasodilatation, thus warm peripheries)

Ultrasound findings for Distributive Shock

Heart

Hyperdynamic(hypercontractile) heart – early sepsis/Anaphylaxis.

Hypodynamic heart/Global hypokinesia – Late sepsis.

Lung

A lines (clear lungs).

Pneumonia (Shred sign,lung hepatization, localized B lines/Unilateral).

IVC

Normal IVC.

High variability of IVC during respiration.

Can be small IVC (if a/w hypovolemia).

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There's nothing more powerful than a humble person with a warrior spirit who is driven by a bigger purpose.
Thank you for major contribution in editing this book, but still wants to remain anonymous.



Simple Guide to Point of Care Ultrasound

It can no longer be denied that ultrasound is now integral to the management of emergency and critical care patient. From differentiating shock to determining the etiology of chest pain, dyspnoea, or abdominal pain, ultrasound has truly changed the way we practice medicine in the 21st century.

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